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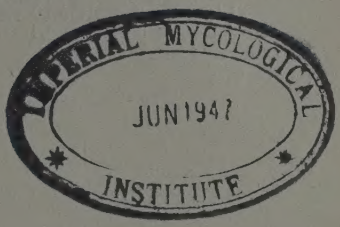

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ERRATA

In the article by V. P. Baturin (C. R. Acad. Sci. URSS, vol. XLIV, No. 3) throughout the article for «cyanite» read «kyanite»

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MATHEMATICS

A NEW GENERALIZATION OF DAVENPORT'S—PILLAI'S THEOREM ON THE ADDITION OF RESIDUE CLASSES

By L. SHATROWSKY

(Communicated by I. M. Vinogradow, Member of the Academy, 20. III. 1944)

In 1935 H. Davenport proved (1) the following theorem.

Let p be a prime integer; $\alpha_1, \alpha_2, \ldots, \alpha_u$, different residue classes mod p; $\beta_1, \beta_2, \ldots, \beta_v$, *also different residue classes* mod p; $\gamma_1, \gamma_2, \ldots, \gamma_w$, *all different residue classes* mod p *of kind* $\alpha_i+\beta_j (1 \leqslant i \leqslant u,\ 1 \leqslant j \leqslant v)$. *Then if* $u+v-1 \leqslant p$, *we have* $w \geqslant u+v-1$, *and if* $u+v-1 > p$, *we have* $w = p$.

The generalizations of this theorem by Chowla (2) and Pillai (3,4) are only concerned with the addition of systems of residue classes of integers.

In this paper is established a theorem on the number of elements in the product of complexes of group elements. It includes the theorems by Davenport, Chowla and Pillai as particular cases.

Besides, some new results can be derived from it.

Let G be a group and let $A=\{a_1, a_2, \ldots, a_u\}$ be a complex of u different elements of G; $B=\{b_1, b_2, \ldots, b_v\}$ a complex of v different elements of G commutable in pairs.

Then the following theorem can be established.

Theorem. *Let $C=\{c_1, c_2, \ldots, c_w\}$ be a complex of all different elements $c_k \in G$ of kind a_i or $a_i b_j (a_i \in A,\ b_j \in B,\ 1 \leqslant i \leqslant u,\ 1 \leqslant j \leqslant v)$.*

Then

$$w \geqslant \max\{u, v, q\}$$

where $q=\min\{u+v, r\}$, *and* $r=\min\{r_1, r_2, \ldots, r_v\}$ *where r_j is the order of elements b_j.*

Proof. The estimation $w \geqslant u$ is obvious. The estimation $w \geqslant v$ follows from the fact that the elements

$$a_i b_1,\ a_i b_2, \ldots, a_i b_v \in C$$

are distinct from each other.

Therefore, it is only necessary to prove that

$$w \geqslant \min\{u+v, r\}$$

for $r > \max\{u, v\}$.

To begin with let $v=1$. Suppose our assertion to be false and $w=u$. Then

$$a_i b_j \in A$$

for all i and j.

But there are r distinct elements of $a_i b_j^{\nu}$, and $w \geqslant r$. This inequality contradicts the assumption $u=w$ for $r > \max\{u, v\}$.

We suppose now that the theorem is proved for $v' < v$. Let $w < r$. We apply the theorem to the complexes $C=\{c_1, c_2, \ldots, c_w\}$ and b_1. There are at least $w+1$ elements of kind c_k or $c_k b_1$ $(1 \leqslant k \leqslant w)$ and, consequently, there is at least one element $d \overline{\in} C$ of kind $c_k b_1$.

As the numeration order of the c_k is arbitrary, they can be so arranged that

$$db_g^{-1}=c_g \qquad (1 \leqslant g \leqslant p)$$

$$db_t^{-1}=e_t \qquad (p < t \leqslant v)$$

$$e_t \overline{\in} C \qquad (p < t \leqslant v)$$

If $p=v$, then

$$db_g^{-1}=c_g \qquad (1 \leqslant g \leqslant v)$$

We consider two cases.

1. $p < v$. In this case

$$c_g b_t^{-1} \overline{\in} A \qquad (p < t \leqslant v,\ 1 \leqslant g \leqslant p)$$

Indeed

$$c_g b_t^{-1} = a \in A$$

implies

$$ab_t = c_g = db_g^{-1}$$

$$ab_t b_g b_t^{-1} = db_t^{-1} = e_t$$

As b_i commute, $b_t b_g b_t^{-1} = bg$ and

$$e_t = ab_g \in C$$

But this condition runs contrary to the definition of e_t.

Hence it follows that $a_i b_t (1 \leqslant i \leqslant u,\ p < t \leqslant v)$ are not contained among $c_1, c_2, \ldots, c_p$ and their number is $w' \leqslant w-p < w$.

As they are made up of the elements $a_i \in A$ and $b_{p+1}, b_{p+2}, \ldots, b_v$, we have by the induction hypothesis

$$w' \geqslant u+v-p$$

and

$$w \geqslant u+v$$

2. $p=v$. In this case

$$c_g \overline{\in} A \qquad (1 \leqslant g \leqslant v)$$

because $c_g \in A$ implies

$$d = ab_g \in C$$

So C contains all elements of A and v different elements $c_g \overline{\in} A$. Thus, our theorem is completely proved.

Many examples of the application of our theorem can be given. We give two particular cases of it.

1. Let θ by an algebraic number; k, the field of rational numbers; and $K=k(\theta)$, the algebraic extension of k. Let $R \subset K$ be the ring of algebraic integers of K, $\zeta \in R$. Then we can apply the estimation of our theorem for addition of systems of residue classes mod ζ, as well as for multiplication of these systems.

2. Let $\mathfrak{P}$ be a prime ideal of R, and $r_1, r_2, \ldots, r_n$ be residue classes by $\mathfrak{P}$.

The estimation of Davenport for multiplication of systems

$$A, B \subset \{r_1, r_2, \ldots, r_n\}$$

can be applied because the group of these residue classes is cyclic relatively to the multiplication of classes and n is a prime integer.

This theorem takes place also for the addition of residue class systems in lattice point sets of the space of n dimensions.

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ASTRONOMY

DETERMINATION OF RADIAL VELOCITIES OF STARS WITH THE AID OF A PRISMATIC CAMERA

By G. A. SHAJN, Member of the Academy, and P. F. SHAJN

The numerous attempts to determine the radial velocities with the aid of a camera supplied with an objective prism have been unsuccessful up to the present time. The only exception was the work by K. Schwarzschild(1), which remained undeveloped, however. It was not until the recent years that positive results have been obtained at the Harvard Observatory and an the Simeis Observatory, independently. We started this work in 1937 using an object-lens 120 mm in diameter and prisms of 17° and 43° (the dispersion for the latter between the Hγ and Hδ being equal to 82 Å/mm). As a screen a 10 per cent solution of $NdCl_3$ was used.

In the course of the experiments three factors were found to be of prime importance: 1) The rigidity of the camera ensuring fixed relative positions of the prism, lens and plate. This, along with the reduced differential refraction and some other conditions, had to secure spectra of the highest quality attainable. 2) A thorough allowance for the variation of the dispersion at different parts of the field. 3) An accurate determination of the systematic error of the radial velocities. An inadequate observance of these conditions makes the work futile, which was probably responsible for the failure of the earlier attempts.

A circumstance independent of the equipment itself should be pointed out here. Until the last decade the principal aim was to determine the radial velocities of individual stars with the aid of slit-spectrographs. The accuracy attained by this method was from a few tenths to 2—3 km, largely according to the type of the spectrum; only in the case of highly diffuse lines the error attained ±5 km and even more. After it became clear that the errors of the radial velocity found with the aid of a prismatic camera were of the order 10 km and even far beyond this figure, even if the errors of the field were neglected, the method seemed to be rather deceitful.

In the light of the new problems of stellar kinematics, however, this opinion should be revised.

At the present time attention should be focussed upon radial velocities of groups of stars as distant as possible rather than upon those of individual stars. We understand here chiefly the determination of elements of galactic rotation, movement of the Sun, of various systematic movements of faint stars and of the new kinematic phenomenon—the negative K term as a function of distance.

With a number of stars sufficiently large it is of no importance on the whole, strange as it may seem, whether the velocities of individual stars will be determined with an error of ±1 km or ±10 km, provided the systematic error be in both cases of the same order, say, 1 km. The systematic error may be sufficiently large, the only essential thing is that it can be controlled with an accuracy

of the order of 1 km. In the modern catalogues the systematic error is usually recorded with an accuracy not exceeding 0.5 km, and sometimes to 1.0 km. In the case of a careful recording of star velocities obtained with the aid of a prismatic camera the latter figure can be attained. This will entirely change our attitude towards the method in question.

One should not think, however, that the radial velocities obtained by this method have the value merely of statistical material. About 30 per cent of the total of the stars of B and A class seem to be spectroscopic binaries, and most of them cannot be detected when the number of observations is 3—4; the catalogue values will thus mostly differ considerably from the true values for the centre of gravity of the system.

In this case the mean velocities, deduced from 6 observations obtained with the aid of a prismatic camera would be probably of greater value. A half of the stars of the B and A type have, moreover, the characteristic *n* (diffuse lines); the accuracy of velocity determinations obtained for them with the aid of a slit-spectrograph is often of the order of ±5 km. For these two categories of stars the prismatic camera can almost compete with the slit-spectrograph. In this case the meaning of these velocities is beyond the statistical one.

The accumulation of data on radial velocities with the aid of slit-spectrographs proceeded but very slowly, in spite of the fact that a considerable amount of the observational work made with the greatest reflectors was devoted to this very problem. Suffice it to say that less than 800 radial velocities were obtained until 1932 for stars of the types B, A and F0—F5 below $6^m.5$. With the aid of a 15-inch prismatic camera the number of radial velocities of these star classes may be increased two or even three times within a few years. This goes to emphasize the advantage of the method. For the sake of illustration, it should be mentioned that the limit magnitude of the Simeis 120-mm prismatic camera is $8^m.8$ with a 2-hour exposure.

For the study of the variation of dispersion with the distance from the centre use can be made of Schwarzschild's theory of prismatic camera. Dispersion D at any point of the plate (x, y) is bound to dispersion D_0 at the centre by the relation:

$$D = D_0 (1 + \alpha y + \beta y^2 + \gamma x^2)$$

where α, β and γ are complex functions of the constants of the object-glass and the prism. For several reasons, however, it seems preferable to make use of the empirical curve connecting the dispersion with the distance from the centre obtained from special observations, instead of one derived theoretically. The observations necessary for this purpose consist in repeatedly photographing the spectrum of the same star with a known velocity across the field of the plate. A fraction of such a photograph is presented in Fig. 1.

By measuring such plate an accurate correlation between the variation of dispersion and the distance from the centre of the plate can be obtained. But as shown by experiment, the relation holds true for the coordinate y only, *i. e.* for the one perpendicular to the refracting edge of the prism. The results of such measurements, giving the reduction towards the centre, are presented in Fig. 2 for Simeis (*I*, *II*) and Abastumani (*III*, *IV*) for distances Hγ—Nd and Hδ—Nd, respectively. The mean values of the reductions for Simeis from observations of 1938 (three plates) and of 1941 (two plates) are denoted by dots and crosses, respectively, in *I*; the dots and crosses are practically coinciding. The distance from the centre of the plate measured in cms is plotted along the abscissa. The positive distances point towards the short-wave lengths. The ordinates are the distances Hγ—Nd and Hδ—Nd, in 0.001 units of a revolution of the micrometric screw (one revolution = 0.5 mm). With this purpose α Lyrae was observed at Simeis, and α Aquilae, at Abastumani.

When treating further observations, we made use of the mean reduction curve, experience has shown, however, that reduction curves should be derived for each day separately. The corrections at Simeis exceeded those at Abastumani; this was

mainly due to the fact that we used prisms of 43° and 17°, respectively. It should be noted that while our reduction curves do not differ by the shape for Hγ—Nd and Hδ—Nd, these curves differ from each other at Harvard.

An important step in the further reduction work was the determination of the normal value of the distance between Hγ—Nd and Hδ —Nd corresponding to a zero

Fig. 1

radial velocity. The simplest solution is apparently to make use of stars with known radial velocities; which would furnish the value of the systematic error for a given plate. The determination of the systematic error is here of paramount

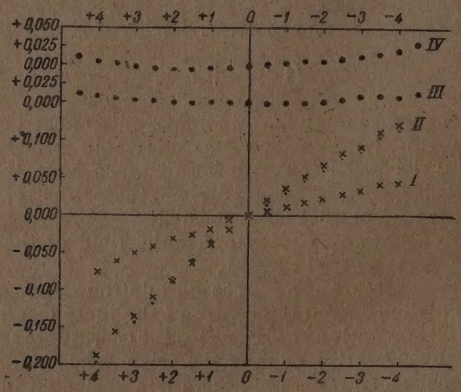

Fig. 2

importance. We were always able to find from 5 to 10 stars with known velocities in our areas (8° × 8°) selected in the Milky Way; this was sufficient for the determination of the systematic error.

Another method should be applied if the number of stars is small. As found from experience, the systematic error may amount sometimes to 40 km for a given plate. It is difficult to decide for the present whether it is caused by the usage of a mean reduction curve, instead of one obtained for the night of observation, or by some other factors. The accuracy in the determination of the systematic error for a single plate when basing on 5—10 reference stars is often of the order ± 5 km. If 5—6 plates are exposed for each area, the systematic error

may be reduced to ± 2 km. In order that such an accuracy be warranted, it will probably be necessary to take two plates during a single night to construct a reduction curve.

With long exposures the effect of differential refraction becomes noticeable, especially if the refracting angle of the prism is a large one, as it was at Simeis. Besides, if a star for guiding is taken from another region, a small displacement of the spectra may possibly occur on the plate, owing to failure of constancy in the relative position of the prism, object-glass and plate during exposure. The accuracy may probably be considerably increased if a star in the field of the prismatic camera itself be used for guiding. In the future we intend to make use of a small guide-spectroscope attached to the plate-holder of the camera itself. Inserting it from time to time into the field of the prismatic camera and intercepting the spectrum of the star chosen for guiding, we shall be able to convert this spectrum into a star again (the direction of dispersion for the little prism of the guide-spectroscope must be opposite to that of the dispersion of the prismatic camera). Although the image of the star will possibly not be quite perfect, guiding in this case will have a considerable advantage over ordinary one.

A certain number of areas of the Milky Way has been obtained by us. For illustration sake we give here the results of measurements of two clusters only (Hyades, 3 plates, and χ, h Persei, 5 plates). The former were obtained at Simeis, the latter at Abastumani. Having selected 11 reference stars with known velocities but not belonging to the cluster (Hyades), we have obtained velocities for 22 stars of the Hyades with known velocities and for 12 fainter stars of the same cluster with unknown velocities. After having rejected three stars with variable velocities, we have determined the velocity of this cluster from the remaining 19 stars to be $\pm 36.1 \pm 1.8$, from the 12 stars (which, judging by their proper motions, also belong to the cluster) the velocity $\pm 38 \pm 4.7$ has been found. Moore's catalogue gives for the 19 stars in question a velocity $+39.5$ km. The mean deviation for a star (irrespective of the sign) between Moore's and Simeis is equal to 9 km.

The work was continued in 1942 at Abastumani. Making use of an 8-inch camera and a 17° prism we have obtained a number of areas in the Milky Way and five photographs in χ, h Persei (the dispersion used is about 130 Å/mm). When measuring the stars of the cluster, we used 12 reference stars without a characteristic c. Basing on these stars, the systematic errors for each plate were determined. We have measured 19 stars with the c characteristic. The mean velocity of the cluster as determined from 19 stars was found to be 42 km ± 4.0 km. According to Moore, the mean velocity of the same stars is equal to 41 km. The mean deviation for a single star (disregarding the sign) Moore—Abastumani equals 20 km.

The figures presented above show that satisfactory results can actually be obtained with the aid of a prismatic camera. It seems quite possible safely to estimate the probable error of the velocity of a single star for Simeis to be of the order of ± 8 km, or even less if the number of plates is brought to 6. It is true, for Simeis and Abastumani we have obtained a systematic error of about -3 km and -1 km. But these figures may be regarded as having a rather haphazard nature, this value will probably decrease for Simeis with the number of plates and stars, inasmuch as, as shown above, the mean deviation from Moore 's catalogue for a single star is two times less than at Abastumani. In the future, making good use of the experience already gained and especially employing the guide-spectroscope, we hope to be able to increase the accuracy and to extend the scope of the observations of the radial velocities of faint stars.

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3. VII. 1944.

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PHYSICS

PROPAGATION OF SOUND IN A HETEROGENEOUS AND MOVING MEDIUM

By D. BLOKHINTZEV

(Communicated by S. I. Wawilow, Member of the Academy, 10. V. 1944)

The modern conditions of war at sea and in the air have brought to the fore the problem of sound propagation in heterogeneous and moving media.

The heretofore established equations for the propagation of sound in such a medium ([1],[2]) suffer from lack of generality, because they implicitly assume the entropy of the medium to be constant, not liable to be disturbed by the motions taking place in the medium. In the present paper the purpose of the author is to establish the most general equations for the propagation of sound in a heterogeneous and moving medium. In these general equations nothing will be neglected but the viscosity and thermal conductivity of the medium, and very little is lost, indeed, by neglecting these factors, since their influence on the propagation of sound can be taken into account separately and notoriously leads to the well-known absorption of sound.

At the basis of our theory will lie the equations of hydrodynamics for a viscous and compressible fluid.

$$\frac{\partial \vec{v}}{\partial t} + \vec{\nabla}\left(\frac{(\vec{v})^2}{2}\right) + [\operatorname{rot} \vec{v},\ \vec{v}] = -\frac{1}{\rho}\vec{\nabla}p + \nu\vec{\nabla}\vec{v} + \frac{\nu}{3}\vec{\nabla}\operatorname{div}\vec{v} - \vec{g} \tag{1'}$$

$$\frac{\partial \rho}{\partial t} + \operatorname{div}(\rho\vec{v}) = 0 \tag{2'}$$

$$\frac{\partial S}{\partial t} + (\vec{v},\ \vec{\nabla}S) = \frac{\varkappa}{\rho}\frac{\Delta T}{T} + \frac{Q}{\rho T} \tag{3'}$$

$$p = Z(\rho,\ S) \tag{4'}$$

where v is the velocity of the fluid's motion; p is the pressure; ρ, density; S, entropy; T, temperature; ν, kinematic viscosity; $\varkappa$, thermal conductivity; Q, energy of motion, converted into heat by internal friction (Q is proportional to viscosity); $\vec{g}$ is acceleration of gravity. Equation (4') is the equation of state in variables (ρ, S) *.

*i If the medium is one of heterogeneous composition (air of variable humidity or water of variable salinity), the equation of state should be somewhat generalized and the system of equatons (1), (2), (3) and (4) completed by adding to it an equation expressing the convection and diffusion of the medium's components.

Suppose that the initial condition of the medium is stable. In the case of propagation of sound all quantities characterizing the initial state will receive small increments, so that $\vec{v}$ will be replaced by $\vec{v}+\vec{\xi}$, p by $p+\pi$, ρ by $\rho+\delta$, S by $S+\sigma$, and so on. Substituting these modified quantities in (1'), (2'), (3'), (4') and disregarding both the higher powers of the small quantities $\vec{\xi}$, π, δ, σ and the terms proportional to ν, $\varkappa$, we shall obtain linear equations of acoustics in a heterogeneous and moving medium, in which no allowance is made for the irreversible effects observed on the propagation of sound. These equations run thus:

$$\frac{\partial\vec{\xi}}{\partial t}+[\operatorname{rot}\vec{v},\ \vec{\xi}]+[\operatorname{rot}\vec{\xi},\ \vec{v}]+\vec{\nabla}(\vec{v},\ \vec{\xi})=-\frac{\vec{\nabla}\pi}{\rho}+\frac{\vec{\nabla}p}{\rho^2} \tag{1}$$

$$\frac{\partial\delta}{\partial t}+(\vec{v},\ \vec{\nabla}\delta)+(\vec{\xi},\ \vec{\nabla}\rho)+\rho\operatorname{div}\vec{\xi}+\delta\operatorname{div}\vec{v}=0 \tag{2}$$

$$\frac{\partial\sigma}{\partial t}+(\vec{v},\ \vec{\nabla}\sigma)+(\vec{\xi},\ \vec{\nabla}S)=0 \tag{3}$$

$$\pi=c^2\delta+h\sigma,\quad c^2=\left(\frac{\partial p}{\partial\rho}\right)_S,\quad h=\left(\frac{\partial p}{\partial S}\right)_\rho \tag{4}$$

Here c^2 is the square of the adiabatic velocity of sound. From these equations it follows that if the entropy of the medium is not constant or if there are vortices in the medium, then the sound vibration will be also of vortical nature ($\operatorname{rot}\vec{\xi}\neq 0$).

Let us consider the most important particular cases. If the entropy of the medium is constant and its motion is irrotational ($\vec{\nabla}S=0$, $\operatorname{rot}\vec{v}=0$), then the sound vibrations appear from (3) to be isoentropic ($\sigma=0$) and, consequently, $\pi=c^2\delta$. Moreover, $\vec{\nabla}p=c^2\vec{\nabla}\rho$. Therefore we can introduce the potential of pressure of the sound wave $\Pi=\pi/\rho$ and the potential of pressure of the initial flow (heat function) $\Pi_0=\int dp/\rho$. Then the right-hand side of (1) will be a complete differential ($-\vec{\nabla}\Pi$), so that the velocity potential of sound vibrations can be introduced in addition, φ ($\vec{\xi}=-\vec{\nabla}\varphi$). In this case the sound vibration will be irrotational. From (1) and (2) after simple computations we obtain

$$\Pi=\frac{d\varphi}{dt}=\frac{\partial\varphi}{\partial t}+(\vec{v},\ \vec{\nabla}\varphi) \tag{5}$$

$$\frac{d^2\varphi}{dt^2}-c^2\Delta\varphi-(\vec{\nabla}\Pi_0,\ \vec{\nabla}\varphi)-\frac{d\varphi}{dt}(\vec{v},\ \vec{\nabla}\lg c^2)=0 \tag{6}$$

Were it not for the last term, this equation would be quite alike with that established by N. N. Andreev and I. G. Rusakov (1). The absence of this term in their equation is an error.

The influence of vorticity on the propagation of sound can be allowed for by means of general equations (1), (2), (3) and (4) if

$$\frac{|\operatorname{rot}\vec{v}|}{\omega}\ll 1,\quad \frac{c\,|\operatorname{rot}\operatorname{rot}\vec{v}|}{\omega\,|\operatorname{rot}\vec{v}|}\ll 1,\quad \frac{v}{c}\ll 1$$

(ω, frequency of the sound), through the substitution

$$\vec{\xi}=-\vec{\nabla}\psi+\int^t[\operatorname{rot}\vec{v},\ \vec{\nabla}\psi]\,dt \tag{7}$$

(ψ is quasi-potential). The equation thus obtained

$$\frac{d^2\psi}{dt^2} - c^2\Delta\psi - (\vec{\nabla}\Pi_0,\ \vec{\nabla}\psi) - c^2\int_0^t (\vec{\nabla}\psi,\ \Delta\vec{v})\,dt - \frac{d\psi}{dt}(\vec{v},\ \vec{\nabla}\lg c^2) +$$

$$+\left(\vec{\nabla}\Pi_0\int_0^t [\mathrm{rot}\,\vec{v},\ \vec{\nabla}\psi]\,dt\right) = 0 \qquad (8)$$

differs little from the one obtained by A. M. Obukhov [2]*. But it is possible also to obtain a more rigorous equation which will, moreover, take into account the changes in the medium's entropy, leading likewise to the curling-up of sound vibrations. Such equation can be obtained as a second approximation of geometrical acoustics.

The approximation of geometrical acoustics is of particular interest, since the equations (6) and (8) have their scope greatly restricted by the assumption that $\vec{\nabla}S = 0$. On the other hand, the full system (1), (2), (3), (4) is very complicated. The geometrical acoustics holds good on the condition that the initial state of the medium suffers no considerable alteration throughout the length of the sound wave $\lambda = 2\pi/k$ ($k = \omega/c$).

In order to obtain the equations of geometrical acoustics we put

$$\vec{\xi} = \vec{\xi}_0 e^{i\Phi},\quad \pi = \pi_0 e^{i\Phi};\quad \sigma = \sigma_0 e^{i\Phi},\quad \Phi = \omega t - k_0\theta \qquad (9)$$

where Φ is the phase; $k_0 = \omega/c_0$ is the wave number in a conventionally normal medium; $k_0\theta$ is the portion of the phase varying with the coordinates; $\vec{\xi}_0$, π_0, σ_0 are slowly changing amplitudes. The substitution of (9) in (1), (2), (3), (4) gives

$$ik_0\left\{q\vec{\xi}_0 - \vec{\nabla}\theta\frac{\pi_0}{\rho}\right\} = \vec{b} \qquad (10)$$

$$ik_0\left\{\frac{1}{c^2}(q\pi_0 - qh\sigma_0) - \rho(\vec{\xi}_0,\ \vec{\nabla}\theta)\right\} = b_4 \qquad (11)$$

$$ik_0 q\sigma_0 = b_5;\qquad q = c_0 - (\vec{v},\ \vec{\nabla}\theta) \qquad (12)$$

where $\vec{b}$, b_4, b_5 depend upon $\vec{\xi}_0$, π_0, σ_0 and do not contain k_0.

Let us suppose k_0 to be large and represent $\vec{\xi}_0$, π_0, σ_0 in the form of series

$$\vec{\xi}_0 = \vec{\xi}_0' + \frac{\vec{\xi}_0''}{ik_0} + \ldots,\quad \pi_0 = \pi_0' + \frac{\pi_0''}{ik_0} + \ldots,\quad \sigma_0 = \sigma_0' + \frac{\sigma_0''}{ik_0} + \ldots \qquad (13)$$

For the first approximation ($\vec{\xi}_0'$, π_0', σ_0') we shall then obtain the equations (10), (11), (13), though deprived of their right-hand side. The condition for solvability of these homogeneous equations leads to eiconal equation

$$|\vec{\nabla}\theta|^2 = \frac{q^2}{c^2} \qquad (14)$$

(q/c can be regarded as the refraction index of the sound waves; its magnitude depends upon the direction of the waves and of the wind). The same equations give

$$\vec{\xi}_0' = \vec{\nabla}\theta\frac{\pi_0'}{\rho q},\qquad \sigma_0' = 0 \qquad (15)$$

So in the first approximation the sound propagates isoentropically. The first equation establishes the relation between the pressure and velocity of sound vibrations.

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* A. M. Obukhov assumes that $c/\omega\vec{\nabla}\lg c^2 \ll 1$, and the equation (8) does not depend upon this assumption.

From the equality $d\Phi/dt = 0$ and from (14) we get the phase velocity of sound waves:

$$V_f = c + v_n \qquad (16)$$

where v_n is the projection of the velocity of the flow on to the normal to the surface of the constant phase. This formula which we have rigorously derived from the theory, was placed by R. Emden [3] at the basis of geometrical theory of sound propagation as one of the initial assumptions. Yet, it is essential not merely to find the geometry of the wave field, but also to evaluate the quantities characterizing the intensity of the sound. For this we have to turn to second approximation. It is easily seen that the equations for the second appoximation will be heterogeneous and their left-hand sides will coincide with the homogeneous equations of the first approximation. Therefore, the conditions for their solvability is that the right-hand sides be orthogonal to the solutions of the adjoint equations. A rather lengthy computation will permit this condition to be represented in the form of the conservation law

$$\frac{\partial \varepsilon_0'}{\partial t} + \operatorname{div}(\varepsilon_0' \vec{V}_S) = 0 \qquad (17)$$

where $\vec{V}_S = c\vec{n} + \vec{v}$ ($\vec{n}$ is the vector of the normal to the wave); $\vec{V}_S$ is the velocity of the energy propagation and ε_0' is the mean energy of the sound, equal to

$$\varepsilon_0' = \frac{\pi_0'^2 c_0}{\rho q c^2} \qquad (18)$$

The mean flow of energy $\vec{N}_0'$ turns out to be

$$\vec{N}_0' = \varepsilon_0' \vec{V}_S = \left(\pi_0' \vec{\xi}_0' + \frac{\pi_0'^2}{\rho c^2} \vec{v} \right) \frac{c_0}{q} \qquad (19)$$

For a tube whose generatrices are directed along $\vec{V}_S$, with a cross-section s, we obtain from (17) and (18) the following relation for stationary processes:

$$\frac{\pi_0'^2 V_S s}{\rho c^2} = \text{const} \qquad (20)$$

From this we can compute the pressure π_0' if it is known at some section of the tube (*e. g.* near the source of the sound). In particular, for a quiet isothermal atmosphere ($c = c_0$, $V_S = c_0$, $\rho = \rho_0 e^{-\alpha z}$) and for a plane wave ($s = \text{const}$) we obtain from (20): $\pi_0' = \text{const} \sqrt{\rho}$, which means that the pressure of the sound wave decreases exponentially with the height z (contrary to this, the velocity of vibrations ξ, as follows from (15), varies directly as $1/\sqrt{\rho}$).

It will be obvious that the condition for the solvability of the second approximation equations permits us to find the expressions for the density of the sound energy and for the flow of energy; and also to establish the equation for the pressure from which the pressure of the sound can be directly determined as soon as the main problem of geometrical acoustics — the finding of rays — is solved.

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GEOPHYSICS

DRIFT SEA CURRENTS IN THE MONSOON FIELD

By W. W. SHOULEJKIN, Corresponding Member of the Academy

The Swedish physicist Eckmann (1) has worked out general hydrodynamic equations for sea currents. He has also applied them to a number of particular cases. In addition to his concrete examples, in 1937 I investigated some cases of currents in a variable field of wind. In the present note I expose the elements of an approximate theory of sea currents liable to arise in the monsoon field: in a closed sea the surface of which is affected by the wind caused by thermal differences of air over the sea and the continent.

As is known, the components G_x and G_y of the d e p t h current, prevailing in the main mass of water, according to Eckmann are expressed by means of derivatives of the altitudes ζ of the point of the sea surface above a certain level surface taken as a basis for calculations:

$$G_x = -k\frac{\partial\zeta}{\partial y}; \qquad G_y = k\frac{\partial\zeta}{\partial x} \tag{A}$$

ζ in its turn is expressed by the differential equation

$$\frac{\partial^2\zeta}{\partial x^2}+\frac{\partial^2\zeta}{\partial y^2}+\frac{k}{B}\left(\frac{\partial H}{\partial x}\frac{\partial\zeta}{\partial y}-\frac{\partial H}{\partial y}\frac{\partial\zeta}{\partial x}\right)=\frac{c}{B}\left(\frac{\partial \mathbf{T}_y}{\partial x}-\frac{\partial \mathbf{T}_x}{\partial y}\right) \tag{E}$$

Here we use the following symbols: H is sea depth at a given point, $\mathbf{T}_x$ and $\mathbf{T}_y$ are the components of the surface friction force of wind action upon the water; then

$$k=\frac{g}{2\pi\omega}, \qquad c=\frac{1}{2\delta_w\omega}, \qquad B=\frac{gD''}{4\pi\omega} \tag{C}$$

where g is the acceleration in the gravity field; ω is the projection of the Earth's angular velocity on to the vertical in the given point; δ_w is the density of sea water; D'' is the so-called «lower depth of friction», *i. e.* the thickness of the stratum of sea water, undergoing the immediate influence of forces arising from the friction on the bottom. This thickness depends on the coefficient of turbulent friction in the water. In general, it is connected with the velocity of the depth current G by a linear correlation cited below. In the expression (E) it was taken to be constant, however.

Only in this stratum is the i n f e r i o r Eckmann's «snail», representing a hodograph of velocities developed, similar to the surface stratum of approximately the same thickness ($D' \approx D''$) where the drift current proper is developed. In the remaining (usually the largest) thickness of water the current velocity G is known to be permanent and has the same direction everywhere: normal to the direction of the fall of the sea level.

It is easy to show that the isohypses of the sea surface, the lines of equal ζ, are in the same time the lines of depth current.

Let us suppose that a sea of circular shape has the same depth H everywhere. Its radius we shall take equal to R. The origin of coordinates we shall place in the centre.

We shall also assume that in the monsoon field (3) the wind velocity is continuously decreasing with the growth of the distance between the coast and the centre and everywhere directed to the radius vector r at an angle α.

We shall not err much if, for the sake of simplicity, we assume that the absolute value of the tangential friction force may be expressed by

$$\mathbf{T} = T_0 \frac{r}{R} \sin\alpha = \mathbf{T}_0 \frac{r}{R} \qquad (1)$$

where $\mathbf{T}_0$, T_0 denote the values corresponding to the sea boundary. In such a manner the main equation (B) assumes an extremely simple form. The expression taken in round brackets in the left part becomes nought, and that of the right part becomes a simple mononome

$$\frac{\partial \mathbf{T}_y}{\partial x} - \frac{\partial \mathbf{T}_x}{\partial y} = \pm 2 \frac{T_0}{R} \sin\alpha = \pm 2 \frac{\mathbf{T}_0}{R} \qquad (2)$$

$\mathbf{T}_0$ denotes the component of friction near the sea coast directed tangentially to the coast line. The sign depends on the season.

Now let us take the polar system of coordinates taking into consideration the fact that, owing to symmetry, $\partial^2\zeta / \partial\varphi^2 = 0$. Then instead of (B) we get:

$$\frac{\partial^2\zeta}{\partial r^2} + \frac{1}{r}\frac{\partial\zeta}{\partial r} = \pm 2 \frac{c\mathbf{T}_0}{BR} \qquad (3)$$

With a stationary regime the conditions at the boundary may be written down as follows

$$\left(\frac{\partial\zeta}{\partial r}\right)_{\text{coast}} = \frac{c}{B}\mathbf{T}_0 \qquad (4)$$

On the grouud of these conditions and putting at zero point the mean sea level, also taking into account the permanency of the full size of water in the sea, we shall get the integral of the equation (3) in the form of

$$\zeta = \frac{1}{2}\frac{c}{B}\frac{\mathbf{T}_0}{R} r^2 + \text{const} = \pm \frac{1}{4}\frac{c\mathbf{T}_0}{BR}(2r^2 - R^2) \qquad (5)$$

Just as in expression (2), the upper symbol corresponds to the winter monsoon season, and the lower, to the summer one. Formula (5) enables us to determine the seasonal variations of the sea level without any changes in the water amount. Thus, we introduce a substantial correction into the usual calculation of water balance.

It is easy to see that the differentiation of (5) enables us to express the velocity G on the ground of (A). Its direction in this case is everywhere normal to the radius r, and its value is determined by the equation

$$G = k\frac{\partial\zeta}{\partial r} = \frac{kc}{B}\mathbf{T}_0 \frac{r}{R} \qquad (6)$$

Later we shall say a few words about numerical calculations.

Now let us examine the currents which are liable to arise in a more complicated case: in a closed sea with an asymmetrical monsoon field. Let the tangential component of friction be expressed

$$\mathbf{T} = \frac{\mathbf{T}_0}{1+\nu} \frac{r}{R_0}(1 + \nu\cos\varphi) \qquad (7)$$

Here T_0 denotes its value corresponding to the point on the coast where $\varphi = 0$; ν is a certain numerical coefficient. Now the equation (B) will take the form

$$\frac{\partial^2 \zeta}{\partial r^2} + \frac{1}{r}\frac{\partial \zeta}{\partial r} + \frac{1}{r^2}\frac{\partial^2 \zeta}{\partial r^2} = 2a(1 + \nu \cos \varphi) \tag{8}$$

as well as

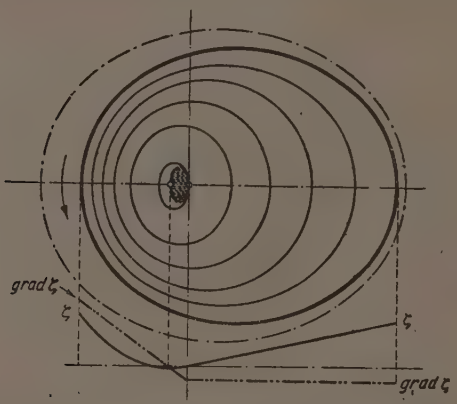
$$a = \frac{1}{1+\nu}\frac{cT_0}{bR_0}$$

The boundary condition (4) will assume the form

$$\left(\frac{\partial \zeta}{\partial r}\right)_{\text{coast}} \approx aR(1 + \nu \cos \varphi) \tag{9}$$

We shall write the general integral of equation (8) in the form

$$\zeta = m_0 r^2 + (m_1 r + n_1 r^2)\cos \varphi + n_2 r^2 \cos 2\varphi + \sum_{\lambda} n_\lambda r^\lambda \cos \lambda\varphi + C \tag{10}$$



Let us confine our examination to the simple case where we can drop all the members of the series under the symbol $\sum_{\lambda}$. The substitution of (10) in (8) gives us

$$m_0 = \frac{1}{2}a, \quad n_1 = \frac{2}{3}a\nu$$

The boundary condition is rewritten in the form

$$\frac{\partial \zeta}{\partial r} = ar + \left(m_1 + \frac{4}{3}a\nu r\right)\cos \varphi + 2n_2 r \cos 2\varphi \approx ar(1 + \nu \cos \varphi) \tag{11}$$

Let the coast line be one of isohypses and simultaneously one of the current lines. Let the distance from the coast to the centre of the coordinates under $\varphi = 0$ be twice as large as under $\varphi = \pi$, *i. e.* $R_\pi = 2R_0$. Then the boundary condition will be satisfied in both of the points marked out, provided:

$$n_2 = \frac{a\nu}{18}, \quad m_1 = -\frac{4}{3}a\nu R_0, \quad \nu = \frac{9}{11} = 0.818$$

Having determined these constants, let us proced to the system of dimensionless values. Namely, first of all we shall assume that $r/R_0 = \rho$ and rewrite (10) in the new form:

$$\frac{2\zeta}{aR_0} = \rho^2 + (1.09\rho^2 - 0.73\rho)\cos \varphi + 0.091\rho^2 \cos 2\varphi \tag{12}$$

For the boundary point under $\varphi = 0$ we shall suppose:

$$\left(\frac{2\zeta}{aR_0^2}\right)_{\varphi=0} = 1.45 = z_0, \quad z/z_0 = \eta \tag{13}$$

Then the equation of the current lines assumes the simplest form

$$(1 + 1.09\cos\varphi + 0.091\cos 2\varphi)\,\rho^2 - 0.73\cos\varphi\rho - 1.45\eta = 0 \tag{14}$$

In the figure we can see these current lines. The solid line represents the coast line. The dot-and-dash line, surrounding the whole diagram, represents the field of the tangential force $\mathbf{T}$ on the coasts: its absolute value is everywhere proportional to the strip of the corresponding radius-vector between the dot-and-dash line and the solid curve limiting the sea. The arrow shows the direction of the component $\mathbf{T}$ during the winter monsoon.

Under the main diagram you see the section of the sea by a vertical plane, crossing the radii-vectors $\varphi = 0$ and $\varphi = \pi$. There we also see the gradients of the sea surface on such a vertical section. They are determined according to the equations which can be easily got from the equation of the sea surface. Namely

for $\varphi = 0$:

$$\frac{1}{aR_0}\operatorname{grad}\zeta = -0.363 + 2.18\,\rho$$

for $\varphi = \pi$: (15)

$$\frac{1}{aR_0}\operatorname{grad}\zeta = -0.363$$

Curiously enough, in the last equation the gradient is constant in spite o the complication of external conditions.

Let us remember that under the condition (6) the wind velocity becomes equal to nought in the pole of the coordinate system, and that the monsoon works over the sea surface in the direction shown by the arrow (winter monsoon). At the same time the gradient of ζ and, consequently, the current velocity G becomes nought not in the coordinate pole, but in another point shown in the figure by a small circle. Taking this into account and comparing the field of the wind with the family of lines of current, we come to the conclusion that on a certain small area lying between these two points the velocities of the depth current have a component opposite to the direction of the wind. In the figure this area is shaded.

Let us now try to calculate the variations of the sea level near the coast line. For this purpose let us substitute in (12) the expression for a written after (8). Then it will prove that

$$\left(\frac{2\zeta}{aR_0}\right)_{\text{coast}} = 2(1+\nu)\frac{B}{c\mathbf{T}_0}\left(\frac{\zeta}{R_0}\right)_{\text{coast}} \tag{16}$$

Now let us substitute in (16) the numerical values used above. Let us remember in particular that the length dimension of the sea will be: $R_0 + R_\pi = 3R_0 = L$.

Then as a result of simple calculations we shall be able to write

$$\frac{\zeta}{L} = 0.127\,\frac{c}{B}\,\mathbf{T}_0 = \frac{0.254\pi}{g\delta D''} \tag{17}$$

Now let us remember Eckmann's expressions (C) for the values c and B, and that the depth of friction D'' can be approximately expressed by means of the velocity of the surface current w (pure drift) and then (4) by means of the wind velocity V:

$$D'' \approx D' = Nw = \frac{NAV}{\sqrt{\sin\varphi}}$$

On the other hand, the same wind velocity V is connected with the tangential force T_0:

$$T_0 = \varkappa_a \delta_a V^2$$

(δ_a, air density; $\varkappa_a$, coefficient of friction).

But if so, it is easy to show that

$$\frac{c}{B} T_0 = \frac{2\pi \varkappa_a}{gNA} \frac{\delta_a}{\delta_w} V \qquad (18)$$

Having substituted here the numerical values of the quantities determined by reliable measurements, instead of (17) we get:

$$(\zeta/L)_{\text{coast}} = 1.8 \cdot 10^{-3} V \qquad (19)$$

here, contrary to the adopted system of absolute measurements, wind velocity is expressed in meters per second.

In the concrete case let

$$L = 9 \cdot 10^5 \text{ m}, \quad V = 10 \text{ m/sec}.$$

Then according to (19)

$$\zeta = 0.16 \text{ m (over the mean level)}$$

During the monsoon change the lowering of the level will reach the value about 0.2—0.3 m, in complete agreement with the observations at sea.

The current velocity itself G in the various zones of the sea and under given complicated conditions may be determined quite easily by means of the equations (11) and (A):

$$G = kar(1 + \nu \cos \varphi) \qquad (20)$$

Near the coast line the expression of velocity will completely coincide with that obtained from (6) through the substitution $r = R$.

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CHEMISTRY

ON THE RATE OF ABSORPTION OF ETHYLENE BY SULPHURIC ACID AT AN ELEVATED TEMPERATURE AND CONSTANT SURFACE ABSORPTION

By V. V. PIGULEVSKY and S. I. ILYINA

(Communicated by V. G. Chlopin, Member of the Academy, 16. V. 1944)

The present investigation was carried out by the manometric method previously employed in an analogous research by Pigulevsky and Rudakova (1), as well as by Davis and Schuler (2).

The experiments were carried out in cylindrical glass reaction vessels having a diameter ~ 10 cm, and internal surface wetted by acid ~ 500 cm^2 and a free volume ~ 1.1 liters. To increase the absorption surface (up to 3000 cm^2 resulting in a decrease in the free volume to 800 ml) the reaction vessel was in some experiments filled with porcelain Raschig rings 15×15 mm in dimensions. The reaction vessel containing 80 ml of H_2SO_4 was placed in a constant temperature water bath with a temperature fluctuation of $\pm 0.5°$ C. To wet the walls with the acid, the vessel was rotated through an angle of 200° every 30 sec.

The ethylene used was a synthetic product (98 per cent) that had been dried in a gasometer over 87 per cent sulphuric acid.

The main experiments were carried out with 95.25—95.5 per cent sulphuric acid (obtained from oleum) at a temperature of 70° C and a partial pressure of ethylene from 800 to 30 mm.

An analysis of the experimental data obtained showed that a semi-log plot of the change in the partial pressure of ethylene as a function of the absorption time gives a straight line for diverse degrees of acid saturation. Moreover, it was found that the experimental data are well described by the equation

$$K\tau = \lg (P_1/P_2) \qquad (1)$$

where P_1 and P_2 are the initial and final partial pressures in mm of Hg, τ is the reaction time in seconds, and K is the absorption velocity constant.

According to this equation, we are dealing here with a monomolecular absorption process, which is explained by the presence of a considerable molar excess of the chemisorbent in comparison with the quantity of ethylene in the system.

Hence, at constant absorption surface the quantity of ethylene absorbed per unit time at a given degree of acid saturation should be proportional to its partial pressure, *i. e.* $\Delta V = mP_1$. This is exactly what is observed in experiment (Fig. 1).

It also follows from (1) that at constant contact time (τ) the ratio of the initial partial pressure of ethylene to the final, P_1/P_2 (and, consequently, the degree of utilization of ethylene as well), remains constant and does not depend upon the initial partial pressure. On the other hand, at constant partial pressure of ethylene the quantity of the hydrocarbon absorbed by a unit surface per unit time

remains constant. Here the degree of utilization of ethylene is inversely proportional to the magnitude of the free volume of the reaction vessel.

Thus, the observed rate of absorption of ethylene (K) depends upon the magnitude of the absorption surface corresponding to a unit of the free volume (S/V). As this quantity increases, there is a proportional increase in the absorption rate constant (see the table). The quantity of absorbed ethylene by a unit of surface in a unit of time at constant partial pressure, on the other hand, practically remains constant.

Reaction vessel				Absorption rate constants × 10^4		Change in magnitude		Ethylene absorbed at P_1=800 mm (in g/m²hr)
Description	S (in cm²)	V (in ml)	$W=\frac{S}{V}$ (in cm²/ml)	observed K	given K	W	K	
Hollow	450	1099	0.41	1.41	3.4	1	1	28.8
Filled with 110 Raschig rings	1823	1048	1.74	6.24	3.6	4.2	4.4	30.6
Filled with 220 Raschig rings	3120	933	3.34	10.9	3.3	8.1	7.8	28.7

This makes it possible to evaluate the given absorption constant C, which does not depend upon the dimensions of the absorption apparatus.

$$\frac{KV}{S}=C \quad \text{and} \quad \frac{K}{W}=C$$

where S is the absorption surface in cm² and V is the free volume in ml.

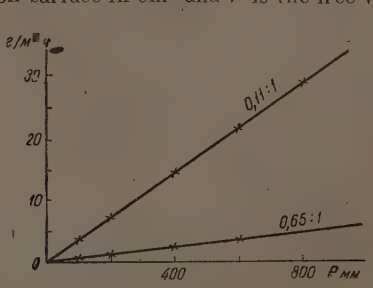

Fig. 1

The last coefficient, $W=S/V$, which express the magnitude of the absorption surface corresponding to unit free volume, characterizes the absorption ability of the absorption vessel. Hence, it may be termed the «effectivity coefficient».

With a fairly big change in magnitude of the effectivity coefficient, the given absorption constants C practically remain constant; moreover, this regularity is observed at diverse degrees of acid saturation (Fig. 2).

Thus, the rate of absorption of ethylene may be expressed by the following equation, independent of the dimensions of the absorption vessel:

$$C=\frac{1}{W\tau}\lg\frac{P_1}{P_2} \qquad (2)$$

where

$$W=\frac{S}{V}\ \text{cm}^2/\text{ml}$$

The following are a few calculated values of the effectivity coefficient computed for diverse absorption conditions: 1.3 for absorption of ethylene in a column filled with Raschig rings 50×50 mm in dimensions; 5.0 for the absorption of ethylene in a column filled with 15×15 mm rings; and 20.0 for absorption of ethylene bubbled without spattering through a column of acid (diameter of gas bubble, 3 mm).

A study of the influence of the temperature upon the rate of absorption of ethylene by fresh 95.5 per cent acid showed that $\lg C$ is a linear function of the reciprocal of the absolute temperature $(1/T)$ (Fig. 3) and that the temperature coefficient of the rate of absorption (10° C) is equal to 1.38.

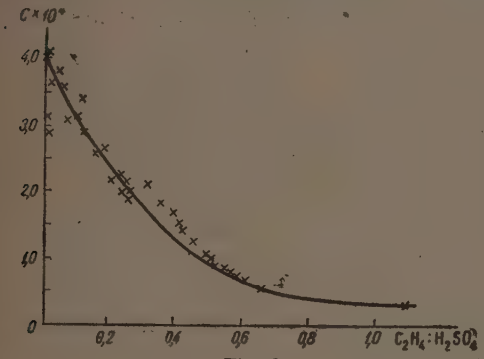

Fig. 2

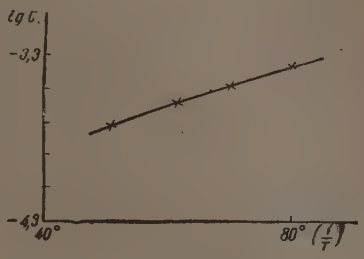

Fig. 3

The influence of the acid concentration upon the rate of absorption of ethylene was studied at 70° C. Relative data are given below.

Acid concentration (in %) . .	86.5	90.4	92.9	95.5	99.4
Relative absorption constant (C for 90.4% acid = 1) . . .	0.5	1.0	1.9	3.6	13.4

With an increase in saturation of the acid, the constant decreases considerably in magnitude. Thus, during the absorption of 1.1 mole of ethylene by one mole of 95.25 per cent acid the constant decreases from $4.02 \cdot 10^4$ to $0.34 \cdot 10^4$, *i. e.* 11.8 times (Fig. 2).

The S. V. Lebedev Plant No. 743.

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GEOCHEMISTRY

THE RESULTS OF SPECTRUM ANALYSIS OF SILICON MINERALS FROM THE PERMIAN DEPOSITS OF TATARIA

By L. M. MIROPOLSKY and S. A. BOROVICK

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Segregations of silicon minerals are widely developed in the Permian deposits within the Tartar ASSR. They are particularly abundant in the deposits of the Kazan stage (1).

Segregations of silicon minerals in the Permian deposits are associated with hypergene migration. Mobile silica is concentrated during the deposition either as individualized segregations of quartz, chalcedony, opal, or jointly, as, for instance, in the case of silicification, or as a component in minerals of a more complex composition—pilolitic, neurotic, asbestos, different kinds of allophanoids and complex gels.

Free silica forms segregations of secretion and concretion types occurring in different stratigraphical horizons. Accumulations of pilolitic asbestos—palygorskite—have as yet been traced only in deposits of the Tartar stage, and those of neurotic asbestos, in Artinskian deposits.

Fifteen specimens were subjected to qualitative spectrum analysis: five specimens of quartz, two of chalcedony, one of opal, four of flint, two of palygorskite, and one of neurotic asbestos.

These specimens have been chosen because of their morphological features being the most typical of the Permian deposits of Tataria.

The spectrographs were taken under the following conditions: the material was burnt in an a. c. 220 V, 10 A voltaic arc flame, the photographs of the spectra of this flame were made on Zeiss quartz spectrograph, Q-24. Two successive spectrographs of each specimen were taken, the second of these gave intenser lines of the difficultly volatile elements and of the ionized atom lines. All of the specimens were analysed for the following 55 elements, Li, Be, B, Na, Mg, Al, Si, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Sr, Y, Zr, Nb, Mo, Ag, Cd, In, Sn, Sb, Te, Ba, La, Ce, Pr, Nd, Il, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tu, Yb, W, Os, Ir, Pt, Tl, Pb and U. Of these, the presence of 21 elements only has been established in the silicon minerals, namely, B, Na, Mg, Al, Si, K, Ca, Ti, Cr, Mn, Fe, Co, Ni, Cu, Ga, Sr, Zr, Ag, Ba, Pb and U.

The place of sampling, their peculiar features, and the results of interpretation of the spectrographs are given in the table.

An examination of the table will lead us to the following conclusions:

1. The minerals of free silica have a simpler chemical composition, a rather low content of accessory minerals, and a negligible concentration of the latter.

2. Asbestos, in particular palygorskite, is characterized by a more complex composition and a higher concentration of some of the accompanying elements.

Place of sampling and peculiar features of samples	Age of deposits	Elementary composition																				
		B	Na	Mg	Al	Si	K	Ca	Ti	Cr	Mn	Fe	Co	Ni	Cu	Ga	Sr	Zr	Ag	Ba	Pb	U
Quartz — rock crystal, transparent, colourless, near the Syukeevo village, on the right bank of the Volga, near the «Syukeev uplift», from caverns of dolomite in the «podluzhnik» . . .	kaz_2 P_2	—	—	5	5	A	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Quartz — white, opaque, at the Pechishchi village, at the right bank of the Volga, near the «ravine», from caverns of dolomite in the «peschany kamen» .	»	2	—	—	—	A	—	4	—	—	—	1	—	—	5	—	—	—	—	—	—	—
Quartz—amethyst, pink-lilac, near the Antonovka village, on the right bank of the Volga, from caverns of silicified dolomitic limestone in the lower part . .	tat P_2	—	—	4	4	A	—	—	5	—	1	a	—	—	5	—	2	—	—	—	5	—
Quartz—amethyst, violet, at the Syukeevo village, from caverns in siliceous concretions of the «podluzhnik»	kaz_2 P_2	2	—	4	—	A	—	3	—	—	1	2	—	—	2	—	—	—	—	—	—	—
Quartz—morion, black, at the Kamskiye Polyany village, on the left bank of the Kama, near «Kamenny Log», from cracks in the lower sandstone	kaz_2cont P_2	2	—	4	2	A	—	3	5	—	5	a	—	—	5	—	5	—	—	—	4	—
Chalcedony — lutecite, bluish-grey, at the Syukeevo village, from concretions in the «podluzhnik» . . .	kaz_2 P_2	2	—	b	5	A	—	4	5	2	—	1	—	—	—	—	—	—	—	—	—	—
Chalcedony — quartzite, bluish-grey, at the Pechishchi village, from siliceous concretions in «shikhany»	»	1	1	2	—	A	—	1	—	—	—	2	—	—	—	—	—	—	—	—	—	—
Opal light-grey, from crusts on gypsum in the lower part	tat P_2	3	—	3	4	A	—	2	4	3	—	4	—	—	2	—	3	—	—	—	5	—
Flint black, at the Shelanga village, on the right bank of the Volga, from the «podluzhnik»	kaz_2 P_2	1	1	2	2	A	—	4	2	—	2	a	—	5	1	—	—	—	5	—	—	—
Flint dark-grey, at the Syukeevo village, from the «podluzhnik»	»	—	b	a	4	A	—	B	4	—	B	1	—	4	5	—	4	—	—	C	—	—
Flint grey, at the Syukeevo village, from the «podluzhnik»	»	2	—	C	2	A	—	1	5	—	2	b	—	—	5	—	—	—	—	—	—	—

Continued

Place of sampling and peculiar features of samples	Age of deposits	Elementary composition																			
		B	Na	Mg	Al	Si	K	Ca	Ti	Cr	Mn	Fe	Co	Ni	Cu	G	Sr	Zr	Ag	Ba	Pb	U
Flint reddish-brown, at the Krasnovidovo village, on the right bank of the Volga, from the «podluzhnik»	kaz_2 P_2	—	—	2	4	A	—	2	—	—	—	a	—	—	5	—	—	—	—	—	—	—
Palygorskite white, at the Krasnovidovo village, Mt. «Krasny Mys», from the lower horizon of marlaceous reddish-brown clays . . .	tat P_2	4	B	A	A	A	1	A	a	1	b	B	—	2	2	2	1	—	—	b	—	4
Palygorskite white, at the Syukeevo village, near the «Ruchzek», from the lower horizon of marlaceous red-brown clays on gypsum . .	»	2	B	A	A	A	b	B	C	a	b	B	5	1	2	2	b	4	—	C	—	2
Asbestos parallel-fibrous, silvery-white, at the Buldyr village, hole No. 22, from the depth of 209.68—213.18 m	A P_1	—	b	B	2	A	—	B	2	4	1	b	—	—	—	—	4	—	—	—	—	—

Symbols of the intensity of lines on the spectrographs: A, extremely intense; B, very intense; C, intense; a, above medium; b, medium; 1, weak; 2, very weak; 3, traces; 4, negligible traces; 5, hardly perceptible.

3. The elementary chemical composition of minerals of the same name taken from different stratigraphical horizons and deposits, does nut fully coincide either qualitatively, or quantitatively.

4. Quartz specimens, with Si playing the leading part, show the presence of B, Mg , Al, Ca, Ti, Mn, Fe, Cu, Sr, Pb and of these, occasionally a high concentration of Fe; a characteristic feature of some of the specimens is the presence of Pb.

5. Chalcedony specimens, with Si playing the leading part, show the presence of B, Mg, Ca, Fe, occasionally Na, Al, Ti, Cr, and of these, occasionally a high concentration of Mg.

6. Opal and flint specimens, unlike quartz and chalcedony, reveal the additional presence in some cases of Ni, Ag or Ba, Cr and Pb being absent; in a few cases a high concentration of Mg, Ca, Mn, Ba and sometimes Na and Fe is observed.

7. Specimens of palygorskite, with Si, Al and Mg playing the leading part, reveal a high concentration of Na, Ca, Fe, sometimes Ba, K, Ti, Cr, Mn, Sr and the presence of admixtures of B, Ni, Cu, Ga, U and sometimes Co and Zr.

8. Neurotic asbestos, with the leading part played by Si, shows a high concentration of Mg, Ca, to a lesser degree of Na, Fe, and the presence of admixtures of Al, Ti, Cr, Mn and Sr.

9. According to the rôle of their occurrence regardless of the composition of the minerals studied, the following elements are distinguished: those always present, Si; those frequently occurring, Mg, Ca, Fe, Al, Cu, B, Ti, Mn; and those but sporadically observed, Sr, Na, Cr, Ni, Ba, K, Ga, Pb, U, Co, Zr and Ag.

10. The majority of the elements are present in the lattice of the minerals as isomorphous admixtures, while the presence of some elements in some particular cases seems to be due to microinclusions, *e. g.* of hydrogoethite, relicts of carbonate rocks, silty components, *etc.*

Unfortunately, the authors have as yet failed to determine a definite relation between the composition of the minerals and the appearance of external morphological peculiarities in the minerals studied.

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GEOCHEMISTRY

ON THE CONTENT AND FORMS OF ORGANIC MATTER IN THE SEDIMENTS OF THE LOWER PERMIAN SALINE LAGOON OF THE NEAR-URAL AREA OF BASHKIRIA

By N. M. STRAKHOV and E. S. ZALMANSON

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In spite of the fact that halogen deposits are rather widespread in the Earth's crust, and that by some authors (as, for instance, Oxenius) they have even been considered as possible oil-producing series, no attempt has so far been made to ascertain for some particular instance the actual quantities and forms of organic matter occurring among the various facies of saline lagoon water basins.

In studying the halogen Kungurian deposits of the near-Ural area of Bashkiria, the authors made an attempt to fill up, at least partly, those gaps in our knowledge. With this object in view, carbon determination by the Knop method was carried out in a series of specially selected specimens. Part of these specimens were obtained from drill-holes of the Ishimbay region; others from natural exposures, from rocks showing no microscopically detectable traces of any secondary organic matter, such as coatings of liquid oil, solid and viscous bitumen inclusions, *etc.*

The lithological composition of the halogenous Kungurian of the near-Ural area of Bashkiria is a rather diversified one. The predominant rocks are blue and grey anhydrites, now extremely pure, now highly contaminated with carbonates and terrigenous material. In the central axial part of the piedmont downwarping, in the lower portion of the halogen formation thick beds of halitites are interbedded with anhydrites, forming a separate Lower Kungurian salt-bearing horizon. Along the western border of the lagoonal formation carbonate rocks are developed (limestones and dolomites), now pure and now distinctly sulphated. Along the eastern Uralian border the halogen deposits are partly (in the lower part of the formation) replaced by terrigenous sediments: clays, marls, sandstones. From this eastern border, long and relatively narrow tongues of red and grey clastic rocks (sandstones, clays, rarely conglomerates) are extending at several places in a westward direction; they replace the synchronous halogen sediments. These tongues (the so-called Allakaev phase of the Kungurian) from the genetic standpoint are subaqueous alluvial fans of numerous river streams, which descended to the Kungurian lagoon from the Ural mountain range located to the East.

Table 1 summarizes the determination of carbon in anhydrites. It is easy to see that all of the petrographical varieties of anhydrite rocks (massive, spotted, thin-bedded) are practically devoid of organic matter which generally appears only in specimens of clayey anhydrites, its content being no higher than 2 or 3 hundredth fractions of a per cent. Accordingly, no traces of organic matter may be detected in anhydrites either macro- or microscopically. It was only at a single part on the western slope of the Urals on the Zilim River at the Aktash village, near the eastern

Table 1

Place of sampling	Mineral insoluble residue	Σ of carbonates	C, %
1. Light-coloured massive anhydrites			
Hole 48/20, depth 443 m	0.36	—	none
» 48/20, » 446 »	0.16	9.11	»
2. Massive grey anhydrites			
Hole 3/4, depth 493—512.7 m	1.31	7.41	none
» 3/4, » 466—484.4 »	0.22	0.27	»
» 10/20 » 912—916 »	0.39	9.30	0.03
» 10/20 » 912—916 »	0.10	1.27	0.01
3. Spotted anhydrites			
Hole 3/4, depth 464.9—469.3 m	5.24	24.40	0.02
» 48/20 » 435 m	13.29	21.34	none (?)
4. Thin-bedded anhydrites			
Hole 10/20, depth 738—748 m	0.95	1.72	0.01
		Average	0.01
5. Anhydrite-clastic rocks			
Hole 48/20, depth 474 m, clayey anhydrite	17.42	25.81	0.60
» 48/20, » 410—416 m, sandy anhydrite	22.73	9.02	0.19

boundary of the halogenous formation, that the authors succeeded to find an insignificant bed of gypsum with abundant highly decomposed vegetable rubbish, evidently supplied to the lagoon by fresh water streams from the Uralian dry land.

No determination of carbon in the halitites was made, but judging from their macroscopic features with regard to the presence of organic matter, the salts are likely to repeat anhydrite rocks.

Table 2

Place of occurrence of the rock	Mineral insoluble residue	Σ of sulphates	C, %
1. Dolomites and calcareous dolomites			
Hole 5/11, depth 567—578 m	0.36	1.02	0.05
» 3/4 » 542.7—547.6 m	4.33	2.81	0.09
» 3/4 » 542.7—547.6 »	3.90	2.77	0.02
» 10/20 » 1033—1043 »	10.26	1.12	0.65
» 10/20 » 1033—1043 »	4.08	10.20	0.30
2. Limestones			
Vill. Timashevka, upper part of the Kungurian	3.26	traces	0.05
Vill. Timashevka, lower part of the Kungurian	18.20	»	0.30
		Average	0.21

As may be seen from Table 2, the carbonate facies is on the whole markedly enriched in organic matter as compared to the sulphate (and chloride?) facies. Those values of carbon which correspond to the maximum in anhydrites, in the carbonate facies lie at the minimum boundary (0.03—0.05 per cent), while the maximum rises far higher, reaching 0.6 per cent. No samples entirely devoid of organic matter have been found among carbonate rocks. The organic matter in the form of ingredient organic debris generally defies macroscopic determination,

and it is but occasionally that fine vegetable detritus is observed. Under the microscope it has the aspect of structureless reddish-brown and black films. Pollen is occasionally encountered.

Table 3

Place of occurrence of the rock	Mineral insoluble residue	Σ of sulphates	Σ of carbonates	C, %
Zigan River at the vill. Armet-Rakhimovo. Clastic series at base of Kungurian				
Sandstone of boundary with Artinskian deposits	62.52	1.22	29.40	0.01
Sandstone over lower gypsum bed	26.48	1.22	68.10	0.11
Sandstone over second gypsum bed	17.86	traces	73.72	0.22
Same (higher up section)	58.30	0.49	32.85	0.26
Marl above second gypsum bed	21.80	1.27	73.52	0.33
Hole 6/11, depth 371—376.2 m, dark marl	28.17	6.16	58.37	0.17
Hole 1/24, depth 886.2—887.2 m, black highly carbonate marl	31.31	1.90	48.90	1.23
Hole 1/23, depth 664.9—667.7 m, same	48.30	2.69	19.76	1.09
Hole 48/20, depth 457 m, dark marl with anhydrite inclusions	24.65	24.9	38.06	1.17
Hole 48/20, depth 462 m, dark sandy clay	38.76	37.00	9.41	1.60
Village of Timashevka, upper part of Kungurian section, calcareous sandstone	35.90	traces	38.45	0.12
Hole 3/25, depth 349 m, cherry-red clay	38.5	26.13	22.04	none
Hole 3/25, depth 1332 m, same	44.38	26.61	16.47	»
Hole 3/25, depth 1380 m, same	63.07	2.30	21.95	0.10

The eastern terrigenous facies can easily be classed into two groups according to the organic matter they contain, *viz.* the grey and red rocks (Table 3). The former (sandstones and marls of Zigan, Timashevka, clays from holes 6/11, 23, 48/20) are distinguished by a marked concentration of organic matter reaching 1.6 per cent, which fully corresponds to the usual amount of organic matter in clays and sandstones. The red rocks, on the contrary, contain very little organic carbon if at all. Macroscopically, organic matter occurs usually as charred fragments of leaves, branches, as well as small pieces of real fusain. In the exposure at the Armet-Rakhimovo village on the Zigan River (western slope of the Urals) the amount of vegetable rubbish in sandstones is so high, and the size of the fragments is so considerable that some areas of the rock represent real cemeteries of branches, wood and leaves. In black clays, in addition to leaf imprints, a large quantity of pollen and spores has been obtained upon elutriation. Under the microscope the presence of organic matter can often be determined after the brownish pigmentation and partly the structureless films observed.

The above data show that:

1) The chemogenic facies of the saline Lower Permian lagoon of the near-Ural area of Bashkiria—anhydrites, halitites, carbonates—are practically devoid of any organic matter, or else it is present in these facies in negligible amounts (traces up to tenth fractions of a per cent). The only sediments concentrating the organic matter are clastic grey rocks of the eastern near-Ural part of the lagoon and of the tongues of the Allakaev facies extending from this area.

2) The organic matter of all the facies of the Lower Permian lagoon is mostly allochtonous, supplied by water streams from the Uralian dry land and then deposited in the lagoon chiefly following the course of settling of clastic particles

and jointly with them. At those points of the terrigenous sedimentation where the surface currents were more intensive (nearer the rivers' mouths), organic matter settled little if at all: here red clastic facies were produced. In the remote and stagnant parts of the lagoon settled the bulk of the organic matter, forming marked concentrations in the silt, reducing ferric iron and yielding grey clastic silts. Deeper in the lagoon, in the areas of subaqueous alluvial fans of the Ural rivers the red silts passed into grey ones. In the silts of the lagoon, no marked accumulation of organic matter has been observed to proceed at the expense of the organic world of the lagoon, in the first place at the expense of phytoplankton.

The mode of occurrence of the vegetable remains deserves great interest. Judging from the charred stems, branches and leaves, from the occurrence of small pieces of fusain, the excellent state of preservation of spores, the processes of conversion of the organic matter brought to the lagoon tended towards carbonization rather than bituminization. In other words, although the grey terrigenous facies concentrated organic matter, they do not seem to have been responsible for the formation of the Kungurian oil that sometimes occurs in Bashkiria; neither were the purely homogeneous facies (anhydrites, salts, carbonates), because of their negligible content or total absence of organic matter.

Whether the Lower Permian lagoon of Bashkiria is a typical basin in this respect, or not, may be shown only by analogous investigations for carbon of other halogenous formations, and particularly of the recent arid water basins.

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GEOLOGY

ON THE PROBLEM OF ORE-BEARING INTRUSIONS OF EAST TRANSBAIKAL

By G. L. PADALKA

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In the course of this work made with the aim to generalize the geological data available on the molybdenum deposits in East Transbaikal, the author has arrived at some conclusions different from those so far present in the literature concerning the young intrusive processes and their relation to the rare-metal mineralization of East Transbaikal. These conclusions are based on field observations carried on within the molybdenum-gold and tin-tungsten belts, east of the 113° meridian, and are of preliminary nature. The evidence available is sufficient, however, to make

General Conclusions Concerning the Intrusive Processes in East Transbaikal. Four principal intrusive complexes may be distinguished, *viz.* the Caledonian, Variscian, Lower Cimmerian and Upper Cimmerian.

The Caledonian complex is represented mainly by granite-gneisses, gneiss-granites, orthogneisses, augen gneisses and cataclazed granites. Less extensively developed are the more basic varieties, gneissose and cataclazed quartz diorites and diorites.

The Variscian intrusive complex is distinguished by a greater variety of rocks, ranging from granites to gabbroes and even to peridotites. Large massives of granites and granodiorites, comparatively small ones of diorites and gabbroes, and quite small ones of peridotites, may be distinguished.

The lower age boundary is determined by a break-through of formations assigned to S_2—D_1 and S_2—C_1, and of the rocks of the preceding complex. The upper boundary is determined by a break of the rocks of the given complex by Lower Cimmerian granitiods, by the presence of pebbles of the given rocks in the Chacha series, assigned to the Upper Triassic.

The Lower Cimmerian complex is represented mainly by biotitic and leucocratic granites. More basic varieties are also encountered, *viz.* granodiorites, quartz diorites, composing areas usually small in size, they are mainly hybrid ones. The vein rocks are aplites, pegmatites, diabase porphyrites.

The lower age boundary offers a break by the given rocks through the Variscian complex. The upper age boundary—the transgressive attitude of I_{1+2} deposits, the presence of granites of this complex in basal conglomerates of I_1, the break of the given rocks by granites of the Sretensk type, in which xenoliths of leucocratic granites have been encountered.

The Upper Cimmerian complex. The three following main stages may be distinguished in the formation of this complex:

1) The main plutons. Shape—roughly elliptical, isometric; size, small—a few km², some dozens, less frequently hundreds km². The enclosing rocks are sandstones and shales, granitoids, limestones and crystalline schists. The intrusion proceeded in several stages. Distinctly porphyry-like granites of the Sretensk type predominate. Less extensively developed are slightly porphyry-like granites and granodiorites and even-grained granodiorites, quartz diorites and diorites. The latter three varieties of rocks have intruded at a later date than the Sretensk type granites. The peculiarities of the granites of the Sretensk type are: variations in composition from granites to granodiorites, distinctly porphyry-like structure, quartz-smoky, isometric, of an idiomorphic habit, coloured components—biotite less frequently hornblende.

Development: the Amudzhikan, Kara-Chacha, Shakthama, Sretensk, Dayn, Bukuka-Belukha, Kukulbei, Durulguev, Zun-Undur, Spokoininsk, Urda-Taptan, Sakhanai plutons.

2) The early stage of additional intrusions. The intrusion took place in several stages. Composition—microgranites, leucocratic and pegmatoid granites, aplite-pegmatites. Mode of occurrence—dykes, veins, and stock-like bodies. Development—in the last 9 of the above-listed main plutons. In the remainder they are but slightly pronounced. The intrusions are situated chiefly within the main plutons and do not extend far into the zones of exocontact.

3) Late stage of additional intrusions. The intrusion took place in several stages. Composition—granite-porphyries, quartz porphyries, granodiorite-porphyries, quartz diorite-porphyrites, porphyrites, lamprophyres. A great variety of structure is observed. These rocks and those of the main plutons are closely related. Mode of occurrence—dykes and stock-like bodies. They occur within the first three of the above-listed main plutons and are little characteristic of the rest. They are found either within the plutons, or in the enclosing rocks. They extend further from the main plutons than the rocks of the early stage. The cooling of many of the given intrusions took place at a shallow depth. The mutual relations between the early and the late stage of additional intrusions may be established from the intersection of the dyke of microgranite with a dyke of granite-porphyry in the Amudjikan deposit, as well as from the position of the additional intrusions with respect to the main plutons.

The age of the given complex is determined from I_2 to Cr_1. Its rocks break through I_{1+2} and in the form of pebbles occur in the Ust-Kara and Turge series (Cr_1).

General Conclusions Concerning the Mineralization in East Transbaikal. There is no room for doubt that with all the intrusive complexes separated out ore deposits are associated; of these the most ancient ones have, as a rule, been more strongly affected by erosion. Certain ore occurrences have been undoubtedly preserved until now, but no criteria are available for distinguishing them from the Mesozoic mineralization which is the most extensively developed one.

The whole of the most important mineralization of East Transbaikal—the rare metal, gold and polymetallic mineralization—is associated by the author with the Upper Cimmerian intrusive complex, or to be more precise, with the additional stages of the formation of the plutons.

Associated with the early stage of the additional intrusions is a tungsten and tin (cassiterite-quartz type) mineralization. The molybdenum mineralization is not characteristic, being manifested only locally and to a small extent. The gold mineralization is absent, the polymetallic one is little characteristic. Examples: the Durulguev, Zun-Undur, Urda-Taptan, Sakhanai, Spokoininsk, Bukuka-Belukha, Kukulbey and Sretensk plutons.

Associated with the later stage is molybdenum and gold mineralization, the latter having appeared later than the former. The tin and tungsten mineralization is not characteristic. The association of polymetallic mineralization with this stage is already perceptible (the Shakhtama deposit), this mineralization became manifest later, possibly at a new stage of magmatic activity passing already into typical effusives.

No observations of the mutual relations between the typical polymetallic occurrences and the magmatic rocks are available.

The molybdenum deposits are situated both at the endocontacts of the main plutons (the Amudjikan, Shakhtama, Kara, *etc.*), and in the zones of exocontacts (the Davenda, Klyuchevskoye deposits), they extend much farther from the plutons than the tin and tungsten deposits.

Gold-ore deposits are located mostly outside the main plutons and extend still farther into the wall rocks, showing either a spatial relation to the intrusions of the additional stage (the Klyuchevskoye deposit), or no relation of this kind (the Pilnya deposit).

The gold-ore deposits are generally isolated from the molybdenum deposits, but in some of the latter gold is present to a marked degree (the Davenda deposit).

In this way the chief stages of mineralization show the following sequence: (1) tungsten and tin (cassiterite-quartz type), (2) molybdenum, (3) gold, and polymetallic. When saying so, it should be emphasized that in Nature there exist no complete isolation of one type of mineralization from another, and it was not infrequent that overlapping occurred.

The distribution of some type of deposits or other depends on different causes; of which the principal ones have been: the territorial distribution of the main plutons of the Upper Cimmerian complexes and the territorial development of some or other stage of additional intrusions. Of no small importance are also the depth of erosion and probably the influence exerted upon the ore processes by the wall rocks.

As a result of a regular distribution of the above-mentioned intrusions, which is closely related to the stratigraphic and tectonic peculiarities of East Transbaikal, a regular distribution of ore deposits is noted in the form of the above-mentioned metallogenetic belts.

It is highly characteristic that within the tin-tungsten belt* we have to do with small main plutons and manifestations of the early stage of additional intrusions. The later stage is either entirely lacking; or represented poorly. Within this belt the molybdenum mineralization is but slight, while the gold and polymetallic mineralization is not characteristic. Within the molybdenum-gold belt following the left bank of the Shilka River and wedging into the tin-tungsten belt (Shakhtama deposit) there are developed main plutons of small size and intrusions of the late stage. The early stage of intrusions is but very slightly pronounced.

The main ore deposits here are the molybdenum and gold ones, the tin and tungsten ones are not characteristic. The polymetallic mineralization here is not strongly pronounced.

We are lacking any data to term the precise idea of the peculiarities of the young intrusives of the polymetallic belt and to compare them to the intrusives of other metallogenetic belts. The peculiar features of this belt are: a very marked predominance of polymetallic, a negligible development of tin, and an absence of molybdenum deposits.

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* Only this territory which lies East of the 113° meridian is taken into consideration.

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GEOLOGY

ON THE PHOSPHORITE OCCURRENCES IN THE CAUCASUS

By R. G. SULTANOV

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A phosphorite deposit was known in South Daghestan(1) near the Kasumkent village since as early as 1916. Somewhat later (4) phosphorite exposures were discovered in Central Daghestan at the Akusha, Khodzhal-Makha and other villages. The Akusha phosphorites (3) are confined to the Upper Aptian, and those of Kasumkent, to the Maestrichtian; the latter deposit is of a secondary nature, being redeposited from the Lower Cretaceous (Aptian).

The exposures of Akusha phosphorites have been very little studied and require further investigation (2). Their P_2O_5 concentration has by chemical analyses been estimated at 17.94 per cent. The Kasumkent phosphorites were the subject of geological-search work involving preliminary estimation of reserves, *etc.*

In 1941 the author carried out additional investigations of the Kasumkent phosphorites, as a result of which two areas have been separated out along the strike: a southern and a northern one. A number of sections along these areas are figured out in the table, against the section of V. P. Renngarten (5) at the Alkodar village, located 5—6 km North of the Kasumkent village. The P_2O_5 content in the phosphorites of Kasumkent varies within the range of 19—26 per cent. From a comparison of chemical analyses of the Akusha and the secondary Kasumkent phosphorites one is led to conclude that at the period of sedimentation of the phosphorites of the latter deposit the conditions must have been favourable for a primary phosphorite-formation. This seems to be evidenced by a higher P_2O_5 content, an abundance of glauconite, probably associated paragenetically with phosphorites; indirect evidence is also the pseudo-oolitic structure of the covering dolomitized limestones (3, 5).

The phosphorite-bearing conglomerate bed of the Kasumkent deposit, wedging out from South to North, varies as to the size of phosphorite concretions contained; thus, in the more southern parts the diameter of the phosphorite concretions attains 3—5 cm and they are but rather slightly rounded, while further North they become more rounded and smaller in size, 1.5 cm and less in diameter. At the Alkodar village their concretions rarely attain 1 cm in diameter, but they are more rounded there. Further North the number of concretions gradually diminishes, they become of a rather scattered occurrence, often in the shape of lenses, still further North at the Nyutyug village this bed of phosphorite (conglomerate) passes into white marls (3), included between dolomitized limestones and Albian clays.

Thus, from South to North the phosphorite bed changes, passing from a conglomerate to sandy rocks with glauconite and further, into carbonate rocks.

More southerly, within the boundaries of Azerbaidjan, in the Kuba region, V. V. Tikhomirov discovered in 1941, in contrast to earlier data, deposits of Upper

First plot, section at the bridge	First plot, section in the head portion of the bed	First plot, section at the stone quarry	Second plot, summary section	Section after V. P. Renngarten at the Alkodar village
1. Dolomitized limestones with small inclusions of phosphorites. Apparent thickness 1.5—3 m. Dip NE 15°, ∠25°	1. Dolomitized limestones with small inclusions of phosphorites. Apparent thickness about 2 m. Dip NE 30°, ∠25°	1. Dolomitized limestones with rare inclusions of phosphorites. Thickness 10—15 m. Dip NE 30°, ∠20°	1. Dolomitized limestones with rare inclusions of phosphorites. Thickness 10—15 m. Dip NE 25°, ∠18—20°	1. Dolomitized limestones. Thickness 50 m. Dip NE 50°, ∠20°
2. Phosphorite bed. Thickness 0.75 m (conglomerate)	2. Phosphorite bed. Thickness 1.1—1.4 m	2. Phosphorite bed. Thickness 0.5 m	2. Phosphorite bed. Thickness 0.15 m	2. Areno-glauconite limestone with very rare spots of phosphorites. Thickness 1 m
3. Limestone with rare inclusions of phosphorite spots. Thickness 1.8 m	3. Limestone with rare inclusions of phosphorites. Thickness?	3. Limestone with rare inclusions of phosphorites in the form of grains. Thickness 3.1 m	3. Limestone with inclusions of phosphorite spots. Thickness 2.5—3 m	3. Phosphorite bed. Thickness 0.16 m
4. Calcareous sandstone with rare inclusions of phosphorites in the shape of grains. Thickness 1 m. Locally inclusions of phosphorites form small lenses linearly persistent	4. Covered	4. Phosphorite bed. Thickness 0.15—0.20 m	4. Calcareous phosphorite-bearing sandstone. In the roof phosphorites in the shape of a lens of the size of a small nut. Sandstones densely strewn with grains of phosphorite. Thickness 2 m	4. Arenaceous marl with rare nodules of phosphorites. Thickness 0.23 m
5. Break in the exposure. Thickness 8—12 m	5. Covered	5. Limestone with rare inclusions of phosphorite. Thickness?	5. Limestone with rare inclusions of phosphorites in the shape of grains. Thickness?	5. Marl, like the preceding one, with still fewer inclusions of phosphorites. Thickness 2—3 m
6. Grey-coloured marls, highly dislocated, cross-bedded, at places covered with a ferruginous film. Dip downstream bridge NE 25°, ∠30°; upstream bridge NE 45°, ∠35°				6. Calcereous brittle travertine with a film structure. Thickness 0.16 m
				7. Soft grey marls locally of a yellowish ochreous colour. Thickness? (Albian?)

Cretaceous rocks, characterized by *Inoceramus* similar to those found in the vicinity of Kasumkent. These data have essentially changed the situation with regard to the stratigraphy of the Cretaceous deposits throughout the region. Therefore the conclusions ([6], [9]) as to the limited local importance of phosphorite accumulation can no more be considered as unquestionable, and the more so as all the materials of the phosphorite-bed sedimentation bear traces of having been carried over from the South and South-East to the North and North-West.

The transgressive attitude of the Upper Cretaceous deposits ([6]) recorded for South Daghestan has also been pointed out for the south-eastern and southern extremity of the Great Caucasus. A large number of glauconite has also been recorded there, which after A.V. Kazakov ([5]) may pass into the phosphorite facies. A. V. Khabakov ([7]), moreover, associates the phosphorite formation with the orogenetic phases and with the phases of the beginning of large-scale sedimentations.

The study of the geochemical facies of sedimentary rocks is known to be given but little attention. After L. V. Pustovalov ([9]) the first to consider this question was V. E. Khain ([4]), who on the southern slope of Great Caucasus separated out a glauconite facies with corresponding formations of glauconite and phosphorite. In the author's opinion, the glauconite facies is confined, with some breaks, to the whole thickness of Cretaceous deposits, to the Maestrichtian inclusively. The glauconite-phosphorite facies separated out ([4]) on the southern slope of the Great Caucasus is probably the result of the phosphorite deposits of Daghestan in the Aptian and Maestrichtian periods.

Some indirect evidence in favour of this assumption may be supplied by the following: the author carried out tests of the P_2O_5 content in some specimens taken at random from the Lower Cretaceous of the southern slope of the Great Caucasus. Contrary to the existing standard ([3]), according to which the content in carbonate deposits of phosphoric acid should vary from 0.3 to 0.4 per cent, in some of the author's specimens the P_2O_5 content was 1.3 per cent.

In this connexion, some interest is presented by the finding of concretions of marlaceous rocks, probably of Cretaceous age, in the region of a bridge across the Samur River at the Khazra village of the Gusarsk region, Azerbaidjan. According to A. Alekperov, engineer, these concretions are scattered in great abundance on the right bank of the Samur-Chai River. Chemical analyses have shown the P_2O_5 content to be within 0.8—1.9 per cent.

As soon as we approach the problem of the Jurassic deposits, we become aware of the lack of chemical analyses for sedimentary rocks with a few rare exceptions only, *viz.* data by V. S. Beliankin, who records a P_2O_5 content of 0.9 per cent in the clay shales at the Arkhotsky tunnel. These deposits of Jurassic shales extend to Daghestan, where they have not been studied at all from this standpoint.

Phosphorite-bearing Tertiary deposits are known in West Georgia in Miocene deposits. There are no data available on phosphorite occurrences in the Cretaceous deposits of the Little Caucasus, but according to the communication of A. K. Shilenko, engineer, it has been discovered in Cretaceous deposits a deposit of phosphorites, in Armenia, along the Megri-chai. Evidence in favour of the presence of phosphorites in Cretaceous carbonate deposits is likely to be secured for the Little Caucasus, too. With regard to the question of a search for phosphorites in the Little Caucasus, V. V. Bogachev says ([1]): «The absence of any indication to phosphorites in the literature is explained by the fact that little attention has been paid to such concretions... The phosphorites in the vicinity of Kasumkent were not described in greater detail by earlier investigators, and were confused with concretions of flint... The phosphorites of the Cenomanian arenaceous limestone near the Olta village did not attract the attention of G. Abich and A. I. Margolius either... I suppose that this fate was shared by some other Caucasian phosphorites». This may be partly confirmed by the following phenomenon: from a specimen of conglomerate of the *Oncophora* beds taken at random near the Kaspi station, Georgia, the author broke out some pebbles in which the P_2O_5 content was equal to 2.5 per cent.

On the question of bed phosphorites L. V. Pustovalov ([9]) says: «although bed exposures of phosphorites may vary considerably in external appearance, in general they very much resemble calcareous and marlaceous rocks, for which they have been and still are sometimes mistaken». They are very much like bituminous carbonate rocks. «The only diagnostic test by which they can be identified is chemical analysis». And this finds support in the fact that the Kara-tau deposit in Central Asia ([8]) has been discovered owing to a mere accident.

W. H. Twenhofen ([10]) points out that the colours of bed phosphorites are due to the presence of some hydrocarbon matter and that these rocks have a strong bituminous smell, and occasionally are even saturated with oil.

A large number of bituminous carbonate rocks have been reported for the Great Caucasus, particularly in the Upper Jurassic and Lower Cretaceous, but no tests for their P_2O_5 content have been made anywhere. We are likely to do with very large bed deposits of phosphorites, but this question cannot be answered until chemical analyses are available, for the genesis and paragenesis of phosphorites, of bed phosporites in particular, have been very little studied.

G. I. Bushinsky ([3]) notes the presence of phosphorite concretions in the Palaeozoic deposits of Armenia. In their most complete section deposits may be traced in the East in the Nakhichevan region. Bushinsky stresses the necessity of a sampling of all the Palaeozoic deposits of the Nakhichevan region, since along the strike the concretions may pass into bed deposits. It should be added that K. N. Paffenholz and Grushev have pointed out the bituminous nature of the Palaeozoic of the Nakhichevan region.

Within the scope of a brief survey of the geological material related to phosphorite occurrences, it should be noted that phosphorites are not alien to the Caucasus ([2]), and that a systematic study of the sedimentary rocks of Caucasus may furnish a clue to a number of questions not only of theoretical but also of practical nature, and solve the problem of the development of phosphorites in the region.

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GENETICS

A METHOD FOR INCREASING WINTERNESS IN WHEATS

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(Commu icated by A. A. Richter, Member of the Academy, 27. III. 1944)

The process of formation of winter sorts among wheat hybrids is connected with the two developmental stages of the parental varieties, *i. e.* with that of vernalization and the light stage. If a definite winter-wheat is crossed with a series of spring-wheats, the number of winter forms within the F_2 is the higher, the longer the light stage of the spring parent. In crosses of a spring sort with a series of winter varieties, the number of winter hybrids among the F_2 is the higher, the longer both development stages of the winter components. This regularity was discovered by us in the spring of 1937, when sowing the hybrids at Besenchuk (Kuibyshev district) (1). In 1938 the regularity revealed by us was checked-up on an extensive F_3 material. These investigations went to confirm the existence of a correlation between the number of the winter forms segregated and the length of the two developmental stages of the parental varieties. They failed, however, to shed any light upon the question as to the comparative qualities of the series of winter hybrids within an individual cross or in different crosses. The length of the vernalization stage of the hybrids, what we call the w i n t e r - h a b i t, is of exceptional both theoretical and practical importance for the understanding of the phylogenesis of winter-wheats and for the breeding of winter-hardy varieties. This article is devoted to the problem of the winterness of hybrids between spring and winter-wheats, as determined from an analysis of the F_3 and F_4 material.

E x p e r i m e n t s w i t h t h e F_3. Among the F_2 hybrids secured from one of the replications of an autumn sowing which had overwintered under a thick snow-cover, plants were selected bearing an amount of seed sufficient to analyse the F_3 progeny for the value of their winter-habit. The seeds of such plant were divided into 4 parts. The one portion of seeds was soaked and kept before sowing at a temperature of 0° C during 54 days, another, during 44 days, the third, during 32 days, the fourth portion of seeds of each individual hybrid line was sown without any pre-treatment. Along with the hybrids, to vernalization treatment were also subjected all parental varieties and several winter varieties differing as to the length of their vernalization stage. The total seed material was sown at once, early in the spring of 1939, at Dniepropetrovsk. The subsequent phenological observations were recorded in the form of a table adjoined to this paper. This table contains the terms when the hybrids, the parental varieties and two varieties more taken for comparison sake came into full earing. Those experimental runs where the plants failed earing, are denoted by a dash, those where but individual plants came into earing, bear out the dates, at which earing set in, in parenthesis. The table embraces but a part of the experimental data, each separate combination is illustrated by no more than 1—2 hybrids displaying different types of winterness.

Types of Winter-Habit of Wheat Hybrids

Varieties and combinations	Nos. of hybrid lines	Date of earing with vernalization during			
		54 days	44 days	32 days	0 days
Prélude		5.VI	5.VI	5.VI	5.VI
Prélude × Cooperatorka	3/2	14.VI	24.VI	(2.VII)	—
Same	3/5	16.VI	22.VI	(27.VI)	—
Cooperatorka		16.VI	24.VI	(27.VI)	—
Prélude × *Lutescens* 329	5/12	15.VI	22.VI	(25.VI)	—
Same	5/15	15.VI	30.VI	—	—
»	5/20	22.VI	(24.VI)	—	—
Lutescens 329		25.VI	(28.VI)	—	—
25183		7.VI	7.VI	5.VI	6.VI
25183×Bg-4	33/16	20.VI	21.VI	29.VI	(27.VI)
Same	33/110	20.VI	19.VI	21.VI	(222.VI)
»	33/20	20.VI	24.VI	26.VI	—
»	33/6	13.VI	18.VI	(16.VI)	—
»	33/124	16.VI	19.VI	(20.VI)	—
Bg-4		24.VI	29.VI	—	—
Erythrospermum 534		11.VI	14.VI	19.VI	—
» 3060/15		8.VI	7.VI	9.VI	(22.VI)
4952		22.VI	21.VI	1.VI	21.VI
4952×Cooperatorka	58/69	21.VI	20.VI	26.VI	(25.VI)
Same	58/2	20.VI	19.VI	29.VI	—
»	58/53	20.VI	22.VI	(25.VI)	—
»	58/68	22.VI	24.VI	(21.VI)	—
»	200/21	20.VI	21.VI	(27.VI)	—
»	200/20	21.VI	25.VI	—	—
»	200/13	21.VI	22.VI	—	—
»	200/14	22.VI	(21.VI)	—	—
»	200/31	18.VI	(19.VI)	—	—
Cooperatorka		16.VI	20.VI	(27.VI)	—
Milturum 321		25.VI	25.VI	24.VI	25.VI
Milturum 321×Cooperatorka	19/57	20.VI	22.VI	22.VI	(28.VI)
Same	19/74	19.VI	22.VI	23.VI	(6VII)
»	19/138	20.VI	22.VI	22.VI	—
»	19/51	19.VI	21.VI	(20.VI)	—
»	19/76	20.VI	29.VI	(3.VII)	—
»	19/37	20.VI	1.VII	—	—
Milturum 321×Bg-21	22/42	22.VI	24.VI	25.VI	(24.VI)
Same	22/176	25.VI	25.VI	29.VI	—
»	22/95	23.VI	24.VI	1.VII	—
»	22/187	24.VI	24.VI	(25.VI)	—
»	22/188	26.VI	(28.VI)	—	—
Bg-21		21.VI	25.VI	—	—

Because of the rather cool weather that prevailed during that spring, the plants underwent after-vernalization on the plot, therefore such a variety as *Lutescens* 329 whose vernalization stage somewhat exceeds 60 days, came fully into ears within the 54 days of the pre-sowing treatment. That the vernalization actually took place after sowing, is also evidenced by the fact that the wheat-plants of the variety *Erythrospermum* 3060/15, whose vernalization stage takes about 10—15 days, started earing without artificial vernalization.

An analysis of the vernalization stage within the winter series of hybrids showed this stage to be subject to important variation. According to the nature of the form-building process, the combinations may be divided into two classes. The first class embraces the three first combinations, here belong the hybrids obtained from crosses between two spring sorts characterized by an extreme brevity of both development stages, *i. e.* of summer-wheats of very high earliness: Prélude and 25183, and various winter sorts of wheat. Only one form-building process has been observed within this class, *viz.* that of segregation of the winter-habit. The wheat varieties produced differ greatly as to the length of their vernalization stage,

ranging from a winter-habit approaching that of the winter parent, and a spring-habit. Quite different is the mode of formation of winterness in the case of segregation of hybrids obtained from crosses between very late spring-wheats and winter-wheats, whose light-stage is shorter than that of the spring components. This class embraces the three last combinations of our table. In this class of plants two form-building processes go on simultaneously, the segregation and the synthesis of the winter-habit. Synthesis leads to the segregation out of varieties with a winterness exceeding that of their winter parents. To such transgressive hybrids belong among others the lines: 200/20, 200/13, 200/14, 200/31, 19/37 b, 22/188. The winter-habit of those hybrids should be recorded as having improved considerably as compared to that of the parental varieties. In some of the hybrids, say in200/14 and 200/31, the length of the vernalization stage is equal to or approaches that of the winter variety *Lutescens* 329. Among the wheats of this country *Lutescens* 329 belongs to the varieties with the longest vernalization stage. Thus, in some of the hybrids the degree of transgression attains 15 days.

On the whole, we are facing here an imposing picture of formation of winter types. It is sufficient to point out three combinations of the second class of hybrids to observe all the types of winterness available in the world collection of winter varieties of wheats. Only such extreme variations are missing as, for example, the wheats of the Scandinavian peninsula, which are known to have the longest stages of vernalization. Dolgushin (2) who analysed the world collection of wheats belonging to the All-Union Institute for Plant Industry came to the conclusion that such a variety of winterness is to be observed only in Italy, Azerbaidjan, Daghestan, Asia Minor and Greece. Curiously enough, it was in these countries that a large number of «semi-winter» types of wheat have been discovered, *i. e.* such forms as come to earing in the case of a long, cool spring when sown in spring, while in the case of a short and warm spring they behave like winter sorts. Flaxberger (3) has for a long time studied the world collection of wheats of the All-Union Institute for Plant Industry. «Semi-winter» types could, according to this author, be found only among samples from such countries and regions where not only winter-, but also spring-wheats, too, are sown in autumn. And this are just the very regions where the wheat varieties have been reported by Dolgushin to display the highest diversity in the length of their vernalization periods.

Among the hybrids of spring- and winter-wheats, large numbers of semi-winter forms are found to segregate out. In our table they are missing in the first two combinations, since being but poorly winter-hardy all of them perished in our experiments. The correctness of this surmise is corroborated by the experiments with the F_2 at various terms of spring sowing. As has already been reported in an earlier note (1), they gave a much larger number of hybrid plants that failed to come to earing when sown late, than in the case of early sowing. The increase in the number of such F_3 hybrids as fail earing (1 time and a half and even more), which takes place when the crop is sown late, proceeds at the expense of such hybrids as have a short vernalization stage, in other words, at the expense of the group of «semi-winter» sorts. This group of wheats is but very poorly cold-resistant. Many plants belonging to this group of our material perished in the second generation during the winter. Nevertheless, such plants could easily be distinguished in the F_3.

A comparison of the data available on the winter-habit within the world collection of wheats with the diversity of the types of winterness among hybrids between spring- and winter-wheats, makes one think that the diversified picture of the winter-habit of wheats in the countries where this crop has been cultivated of late, could hardly arise without natural hybridization between spring- and winter- or semi-winter wheats. This process may still be operative in such countries where both winter- and spring-wheat varieties are sown in autumn, especially in the case where mixed seeding material is used.

Alongside of the investigation of the length of the vernalization stage in F_3 hybrids, the winterness of F_4 hybrids was also studied on a material of different origin. The distinctive trait of the experiments made with the fourth generation consisted in that the same lines were tested both for their winter-habit and winter-

hardiness. The F_4 hybrids were found to display similar pictures of segregation and synthesis of a long vernalization stage. Transgressions for winterness were obtained again in three combinations derived from crosses between three varieties of spring-wheat having a long light stage, with the winter-wheat Cooperatorka. In some of the hybrid lines the transgression amounted to 10—15 days.

Of extreme importance is the well-pronounced parallellism in the variation of winter-habit and winter-hardiness. Lines showing a considerable transgression of winterness were found to be much more winter-hardy than the two parental varieties. We started our experiments with the original number of 250 F_2 seeds for each combination in each replication of the experiment. Considering the pair-assortment here described, the rate of transgression should be regarded as a rather high one. Parallel variation is known to be of wide occurrence in the vegetable kingdom. The use of our principle of pair-assortment for the production of transgressive variation in hard wheats and other grasses is therefore likely to lead to the production of varieties with a more expressed winter-habit and with a higher cold-resistance than in those actually available. In the case the cause of the transgression of winter-habit here suggested will be confirmed by experiments with two spring plants, it will be possible to create new varieties with a more pronounced winter-habit. which is of no small importance for the cultivation of a number of root-crops.

Conclusions

1. The process of the formation of winter-habit in wheat hybrids depends, both quantitatively and qualitatively, on the length of the two developmental stages of the parental varieties, the vernalization and the light stage.

2. In all the hybrids between spring and winter varieties there is observed segregation of the winter-habit, *i. e.* segregation-out of various types of winter-habit, ranging between the type of the winter parent and spring sorts.

3. In hybrids from crosses of spring-wheat varieties with a longer light stage than that of the winter component, two processes are going on: segregation and synthesis of winter-habit. As a result, varieties with a vernalization stage longer than that of the winter parent, are found to have segregated out.

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PLANT PHYSIOLOGY

EFFECT OF ALKALINIZATION OF SOIL ON THE INTENSITY OF PHOTOSYNTHESIS IN DIFFERENT SPECIES OF COTTON

By L. P. ZHDANOVA

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Numerous experiments, as well as farming experience, demonstrate that the effect of soil alkalinization (soil solutions high in salts, chiefly in NaCl, Na_2SO_4 and Na_2CO_3) is to reduce the total yield of the crop.

One of the principal factors accounting for the decrease in dry weight of plants cultivated on soils high in those salts is the reduced intensity of their photosynthesis ([1], [2], [7], [11]). According to Monfort ([10]), the inhibiting effect of alkalinization upon assimilation is more conspicuous in poorly salt-resistant plants, the mesophytes; the assimilation apparatus of halophytes is more resistant to the influence of salts and of chlorides, in particular.

Table 1

Comparative Height of Cotton Plants Grown on Alkaline or Saltless Soils

Cotton species	Conditions of soil	Height of plants in cm
Gossypium barbadense	1st term of salt treatment	32.0
» »	Control	45.0
G. hirsutum	1st term of salt treatment	37.0
»	Control	45.0
G. herbaceum	2nd term of salt treatment	36.0
»	Control	53.0
G. hirsutum	2nd term of salt treatment	35.0
»	Control	45.0

The present work was undertaken with the purpose to bring out the effect of salts upon photosynthesis in several species of *Gossypium* differing as to their salt-resistance. The experiments were carried out at the plot of the Tashkent Institute of Botany and Soil-Science (Uzbek branch of the Academy of Sciences of the USSR), during the summer 1942.

Representatives of 3 cotton species differing as to salt-resistance served as experimental material: *Gossypium barbadense* (Egyptian No. 0270), *G. hirsutum*

(American No. 8196) and *G. herbaceum* (Guza No. 2923). Sowing was done on June 17th with seeds previously soaked in water during 5 hours. The seeds were planted in metal vessels containing 10 kg of absolutely dry soil which was a local loamy grey-soil. The humidity of the soil was kept throughout the period of growth at 60 per cent to total moisture capacity. Each vessel was made to contain a single plant. After sprouting, part of the plants were transferred to alkaline soil, which was brought about by regularly adding during ten days small portions of equilibrated Vant-Hoff—Richter saline solution, until the concentration of chlorine was brought to 0.2 *N* per vessel. Transferred to alkaline soil, part of the *G. hirsutum* and *G. herbaceum* plants perished after a short while; a new set of these plants was transferred to alkaline soil in the middle of July. Control plants were left to grow on a soil without any salt addition. The experiments were run at twofold replication.

The plants transferred to alkaline soil displayed an inhibited life activity: the stage of budding and that of flowering set in some 2 or 3 days later than in the controls. The processes of growth were also inhibited in those plants, which was especially pronounced in *G. herbaceum* (Table 1). It should be pointed out that the plants transferred to a soil with a high salt concentration showed also an inhibited development of both their vegetative and reproductive organs. In this respect the

Table 2

Photosynthesis Intensity in Different Cotton Species as Affected by Alkalinization of Soil

Date	Hour	Temperature of chamber, °C	Species of cotton	Conditions of soil	Intensity of photosynthesis in mg CO_2 per 50 cm^2 within 60 min.
27.VIII	10.35	30	*G. barbadense*	1st term of salt treatment	4.52
			»	Control	4.85
	11.58	32	*G. hirsutum*	1st term of salt treatment	Evolution of CO_2
			»	Control	0.88
31.VIII	10.30	36	*G. barbadense*	1st term of salt treatment	5.35
			»	Control	4.21
	11.48	38	*G. hirsutum*	1st term of salt treatment	4.97
			»	Control	5.09
25.VIII	9.40	36	*G. herbaceum*	2nd term of salt treatment	0.77
			»	Control	1.53
	11.15	38	*G. hirsutum*	2nd term of salt treatment	6.03
			»	Control	6.12
29.VIII	8.40	30	*G. herbaceum*	2nd term of salt treatment	Evolution of CO_2
			»	Control	4.84
3.IX	9.44	37	*G. hirsutum*	2nd term of salt treatment	1.55
			»	Control	1.44
21.IX	11.11	30	*G. herbaceum*	2nd term of salt treatment	4.62
			»	Control	7.65
	12.14	35	*G. hirsutum*	2nd term of salt treatment	2.87
			»	Control	2.17

most badly affected was the selected variety *G. herbaceum* again, while *G. hirsutum* and *G. barbadense* plants went on better.

By the end of the experiment the yield was not recorded, since leaf samples were taken for photosynthesis determinations; the latter were started on August 25th.

The intensity of photosynthesis was measured with the aid of Richter apparatus in individual leaves severed from medium internodes, each separate test comprised leaves taken from the same part of a plant. The results of determinations of photosynthesis in different varieties, on soils of low or high salt concentrations, are summarized in Table 2.

The figures of Table 2 depict the Asiatic cotton variety, *G. herbaceum*, as having an assimilation apparatus more susceptible to the injurious influence of soil alkalinization, than those of the American and Egyptian species (*G. hirsutum* and *G. barbadense*). The behaviours of the individual species are so different that even corrections for respiration being made (respiration was not determined in these experiments), the relations revealed nevertheless remain stable.

The next experiments were made with the purpose clearly to exhibit the effect on photosynthesis of sodium salts when introduced directly in the green leaves unsevered from the mother plant. Unlike the case of soil alkalinization where we were facing a summarized ionic and osmotic influence of the salts upon the whole plant ([3]), in this case we evidently had to deal with a direct ionic effect of the salts upon the colloids of the plasm of the leaf. The possibility of a direct supply of salts to the leaf and the mechanism of this process have been pointed out by Mazkov and Farfel ([4]).

In our experiments the leaves of medium internodes of *G. hirsutum*, *G. barbadense* and *G. herbaceum* were moistened with 0.1 *N* solutions of sodium chloride

Table 3

Intensity of Photosynthesis in Different Cotton Species as Affected by Treatment of Leaves with NaCl and Na_2SO_4 Solutions

Date	Hour	Temperature of chamber, °C	Species of cotton	Treatment	Photosynthesis intensity in mg CO_2 per 50 cm^3 within 60 min.
15.IX	11.17	27	*G. herbaceum* 7010	0.1 *N* NaCl	2.93
			»	Control	6.96
19.IX	11.00	27	*G. barbadense* 2451	0.1 *N* NaCl	5.12
			»	Control	5.48
	13.02	35	*G. hirsutum* 2470	0.1 *N* NaCl	3.55
			»	Control	3.68
	12.36	32	*G. herbaceum* 7010	0.1 *N* NaCl	13.51
			»	Control	17.85
6.X	13.30	28	*G. hirsutum* 8196	0.1 *N* NaCl	5.33
			»	Control	6.20
	11.15	27	*G. herbaceum* 2923	0.1 *N* Na_2SO_4	Evolution of CO_2
			»	0.1 *N* NaCl	1.85
			»	Control	5.26
7.X	14.20	32	*G. barbadense* 0270	0.1 *N* Na_2SO_4	1.47
			»	0.1 *N* NaCl	2.11
			»	Control	3.04
	13.12	32	*G. hirsutum* 8196	0.1 *N* Na_2SO_4	3.03
			»	0.1 *N* NaCl	4.46
			»	Control	6.31
	10.50	28	*G. herbaceum* 2923	0.1 *N* Na_2SO_4	2.64
			»	0.1 *N* NaCl	4.18
			»	Control	9.06

and sodium sulphate; leaves treated with pure water served as controls. The treatment was practised at early morning hours during three days. Table 3 contains the results of some of the determinations of the intensity of photosynthesis in experimental and control leaves taken from corresponding internodes of cotton plants of the three species under comparison.

From the figures of Table 3 it may be inferred that the effect of salt-treatment of leaves is to reduce the intensity of photosynthesis. In this case, as in the case of alkalinization of soil, the most badly affected are the varieties of *G. herbaceum* again, while both in *G. hirsutum* and *G. barbadense* the photosynthesis is found to be less strongly inhibited.

It is of interest to note that under the experimental conditions here described the inhibiting effect of sodium sulphate was more sharply expressed than that of sodium chloride. It should also be emphasized that the relation existing between the intensity of photosynthesis and the salt resistance of a vegetable organism is a much more complicated one than one might suppose on the basis of those tests alone. This relation is underlain by changes in the physical-chemical properties of the colloids of the plasm and its inclusions ([8], [9], [11]), which are brought about by alkalinization; it is these changes that determine the intensity and the trend of all the functions of a live cell and an organism as a whole. Here belong the processes of development and growth ([6]), of photosynthesis ([12]), the work of the enzymatic apparatus ([5], [3]) *etc.*

Thus, the experiments carried up by us with cotton species make it possible to establish a correlation between the degree of inhibition of growth processes and, consequently, the yield of the plants, on the one hand, and the value of the drop in the photosynthesis intensity, brought about by the alkalinization, on the other. The relative value of the inhibition of photosynthesis in representatives of the three species compared—the Egyptian, American and Asiatic one—are not dependent on the mode of salt-treatment, *i. e.* on whether it is administered through the root system or directly to the leaf. In either case, it is the varieties of the Asiatic species which are found to be the most susceptible to the toxic effect of the chlorides; the compared varieties of the Egyptian and American cotton prove to be more resistant to the treatment.

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ENDOCRINOLOGY

INFLUENCE OF LIGHT UPON THYROTROPIC ACTIVITY OF ANTERIOR LOBE OF PITUITARY BODY

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It may be considered as safely established by now that the basophilic cells of the anterior lobe of the pituitary body produce substances affecting the work of several organs of the endocrine system, in particular, of the thyroid gland and the gonads. The activity of the anterior lobe is dependent on light; the effect of the latter is to increase the production of the hormone stimulating activity of the sex-glands. It has been demonstrated that by exposing the animals to intense illumination, or, inversely, by withdrawing light it is possible to bring about a number of alterations in the microscopic structure of the pituitary body. If a frog is withheld from light, the anterior lobe of its pituitary gland is found to contain a reduced number of basophilic cells; occasionally these may even vanish altogether. Illumination has a stimulating effect upon the development of basophilic cells which finish by supplanting of all other types of cells (3). By grafting hypophyses of birds exposed to light (drakes) to infantile mice, Benoit (1) succeeded in demonstrating that under the influence of light the tissue of the pituitary body becomes enriched with the gonadotropic hormone. Fiske (2) who carried out analogous experiments with mammals, obtained no clear-cut results, however.

The microstructural alterations that take place in the pituitary body are undoubtedly caused by those functional shifts which proceed in the anterior lobe, in its basophilic apparatus under varying light conditions.

The mechanism underlying the dependence of the gonadotropic function on the factor of light has been dealt with in a number of papers; the probable dependence of the thyrotropic function on illumination has, on the contrary, been entirely neglected by investigators. The fact that both tropic hormones are localized in the same secretory cells makes us think of the production of the thyrotropic hormone as being dependent on light.

The present work is the first attempt to bring out the dependence of thyrotropic activity upon light, the conclusions suggested are based on experiments carried out on *Anura*.

The frogs *Rana ridibunda* were kept in terraria, some of which were continuously illuminated by an electric bulb, while the other were deprived of any illumination. Each experimental run thus comprised two sets of animals.

During the two spring seasons, of 1942 and 1943, a total of 12 experimental runs were carried out, with periods of illumination ranging from 3 to 20 days. A total of 186 sex-mature frog females were under experiment; the animals were, as a rule, caught from nature after the period of spawning.

After each experiment the pituitary glands of the animals were either fixed for histological examination, or mostly used for biological tests.

In order to determine the degree to which the tissue of the hypophyses of the frogs in the sets under comparison was enriched with the thyrotropic hormone, larvae of the same species were used as test-objects. The grafting of a tadpole with hypophysal tissue does not accelerate the metamorphism unless the graft contains the thyrotropic hormone whose effect is to activate the thyroid gland of the larva. The rate of the resorption of the larval organs may thus be taken clearly to reflect the degree of activation of the thyroid gland, being at the same time an index of the thyrotropic activity of the hypophysal tissue transplanted. Dependable indices of metamorphic changes are such organs of the larvae, as the tail and intestine, which are largely or entirely resorbed at the period of metamorphosis.

Weighed portions of pituitary glands, 1 mg each, taken from frogs of different sets, were grafted into the abdominal cavities of tadpoles. The tadpoles which served as test-objects had preliminarily been so assorted as to be similar with respect to their stage and size. Tadpoles in a stage considerably preceding natural metamorphosis were chosen, when the posterior limbs are present in the shape of oval buds.

As controls to each experimental run served a third run in which the tadpoles underwent to no transplantations. As soon as metamorphic changes became observable in the experimental runs, the tadpoles of all the three runs were sacrificed simultaneously. By measuring and weighing the resorbing organs in every larva, data have been obtained according to which the intensity of metamorphosis could be evaluated in an unprejudiced manner. In Tables 1—3 are given the means for every indicator within each experimental run; they also show the difference between the control and the experiment for every indicator, in per cent to control.

Table 1

Thyrotropic Activity of Frog Hypophyses Tested Biologically on Tadpoles

Duration of experiment	Run	Length of intestine		Body weight		Tail weight		Total difference of effect
		in mm	difference in %	in mm	difference in %	in mm	difference in %	
5 days	Control	127	—	735	—	202	—	67 6
	Dark	91	28.3	551	25.1	134	33.6	
	Light	46	63.8	449	38.9	97	51.9	
10 days	Control	186	—	625	—	145	—	20.2
	Dark	71	62.0	475	24,0	120	17.2	
	Light	52	71.4	437	30,1	113	22.1	
15 days	Control	177	—	825	—	185	—	9,9
	Dark	71	60.0	551	32,0	153	17.3	
	Light	63	64,4	528	36,0	150	18.8	

In order not to make our table too cumbersome, data are given for 5-, 10- and 15-day-long experiments only. A maximum increase in the thyrotropic activity of the pituitary body is produced by a short exposure to continuous illumination (5 days). If the tadpoles are grafted with hypophyses of frogs of the two sets of this group, the metamorphosis sets in much earlier in the run involving exposure to light than in that kept in the dark. The total difference in the effect obtained in the experimental runs for the three indicators makes up 67.6 per cent. By doubling the light exposure (up to 10 days) no increase in the biological effect is obtained. On the contrary, the thyrotropic activity of the pituitary glands in the illuminated set is found to decrease (the total difference coming up to 20.2 per cent). A further increase in the length of exposure is accompanied by a further reduction of the thyrotropic activity. Thus, under conditions of continuous illumination the biological activity of the pituitary body is found to increase considerably during a short while, after which it begins to decrease, although the illumination is not

discontinued. This conclusion is substantiated by the data of the tests repeated on frogs and toads. It should be pointed out, however, that the tissue of the pituitary gland was invariably endowed with thyrotropic activity, the degree of which varied according to the experimental conditions.

From the figures of Table 1 it may be concluded that a volume unit of hypophysal tissue activated with light contains larger amount of the thyrotropic hormone than that of animals kept under conditions of absolute darkness. Special tests were undertaken in order accurately to evaluate the degree to which the pituitary body is enriched with the thyrotropic hormone under the influence of light. In these experiments the sizes of the bits of the hypophyses grafted to the tadpoles of the «dark» set were gradually increased. As a result, a dosage was established which led to the equilibration of the effect (Table 2).

Table 2

Biological Effect Observed in Tadpoles Grafted with Bits of Hypophysal Tissue of Different Weight

Weight of graft in mg	Run	Length of intestine		Body weight		Weight of tail	
		in mm	difference in %	in mg	difference in %	in mg	difference in %
—	Control	139	—	522	—	125	—
1.5	Dark	53	61.8	360	31.0	88	29.6
1.0	Light	49	64.7	354	32.2	89	28.8

As seen from the table, the thyrotropic activity of the pituitary glands activized with light exceeds that of the glands of animals kept in absolute darkness by about 30 per cent. In order that the morphological effect be analogous in both sets, the weight of the bits of hypophyses taken from animals kept in the dark is to be increased by a third.

A short light exposure has thus been found to increase the amount of the thyrotropic hormone in the tissue of the pituitary body. Lengthy illumination seems to lead to an exhaustion of the hypophysal tissue which shows but a poor activity when subjected to biological tests. It is therefore possible to assume that under natural conditions the effect of prolonged illumination is to reduce the enrichment of the hypophysal cells with the thyrotropic hormone. In this case an additional short-lived illumination of frogs caught from natural conditions, not in spring but in summer, can no more increase the biological activity of the pituitary body. Indeed, special experiments went to corroborate this assumption (Table 3).

Table 3

Metamorphosis in Tadpoles as Induced by Grafting with Hypophyses of Frogs Taken from Nature in July and Kept during 7 Days under Contrast Conditions

Run	Length of intestine		Body weight		Weight of tail	
	in mm	difference in %	in mg	difference in %	in mg	difference in %
Control	226	—	871	—	214	—
Dark	45	80.0	614	29.5	176	17.8
Light	61	73.4	744	14.6	188	12.1

As seen from this table, the pituitary bodies of summer frogs which had been subjected in the laboratory to continuous illumination, proved even less active than those of the amphibians withheld from light.

The examination of histological preparations taken from different sets revealed a microscopic picture which was in full agreement with the results of the biological tests. The number of basophilic cells in the pituitary body was found to increase under the influence of illumination, the protoplasm of these cells is strongly granulated. In the experiments with short exposures no shift in the quantitative relations between the various types of secretory cells was observable, but in these experiments, too, typical alterations in the structure of the basophilic cells could be recorded. The number of these cells decreased appreciably in the dark. They were always present in the hypophysal tissue of the test animals, irrespective of the conditions and length of illumination which varied within a rather wide range. This accounts for the fact that the pituitary glands of the animals of the experimental sets invariably produced a metamophogenic effect whose degree varied according to the conditions of the experiment.

From the data discussed above it can be concluded that light has a stimulating effect upon the secretory activity of the basophilic cells and upon the supply of the hormone to the humoral medium of the organism. A prolonged illumination must necessarily result in a reduction of the content of the hormone in the hypophysal tissue. This does not take place, as it seems, under conditions of intermittent illumination or in the absence of light.

The structure of the pituitary body is extremely labile to the influence of light: variations in the light-regime during 1—2 days are sufficient essentially to change the microscopic picture of the gland. It seems therefore but natural to assume that the 24-hour rhythm in the alternation of the periods of light and dark (day and night) had an influence upon the mechanism of the anterior lobe of the pituitary body which developed during the phylogenesis. The effect of light is favourable for the secretion of basophilic cells, whose hormone under these conditions is intensively eliminated into the blood stream. Unlike this, the absence of light stimulates the reservation of the active principle in the cells of the pituitary body. Under the conditions of the 24-hour periodicity the function of the thyroid gland activized by the thyrotropic hormone does not suffer any sharp fluctuations throughout the year. The regular variations in the ratio of the lengths of day and night during different seasons are accompanied by a shift in the function of the pituitary body; either of the two phases, that of elimination or reservation of the hormone prevails during a definite period. During the spring period, when the phase of elimination prevails, the concentration of the hormone in the humoral medium of the organism attains the threshold of reaction on the part of the tissue of the gonads. In the case of a high concentration of the thyrotropic principle, as well, part of the latter is likely to transform into the gonadotropic one, in the same way as the male sex hormone, when attaining high concentrations, is partly transformed into female one.

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